

Neighborhood Walkability, Perceived Stress and Telomere Length: Is there a relationship?

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Abstract

Purpose and Background. Pregnant Black women are more likely to live in disadvantaged neighborhoods (i.e., vacant housing) and have higher levels of perceived stress compared with pregnant White women. Living in disadvantaged neighborhoods has been related to biological markers of stress including shorter telomeres, tandemly repeated nucleotide repeat sequences (TTAGGG) at the end of the chromosomes, among non-pregnant Black women. This pilot study examined the associations among neighborhood walkability, perceived stress, and telomere length among pregnant Black women.

Theoretical framework. The Theory of Allostatic Load states that chronic cumulative exposure to stressful situations results in alterations of biological processes and ultimately increase risk for adverse health outcomes.

Method. This pilot study includes pregnant Black women (n=61) who participated in a larger prospective study that examined the role of maternal factors on birth outcomes among Black women. Eligibility criteria included: self-identified as Black or African American, age 18-45, singleton pregnancies, <30 weeks gestation, read/write English. Women completed the Neighborhood Walkability Scale and the Cohen's Perceived Stress Scale between 19-29 weeks gestation. Telomere length was analyzed from salivary samples using the monochromic multiplex quantitative polymerase chain reaction (MMP-qPCR). Descriptive statistics were used to describe the sample. Pearson's *r* correlation coefficient was used to examine the associations among variables.

Results. Women had a mean age of 26.5±5.8 years (range 18-40). The majority of women graduated high school or had technical/vocational training (57%), were single (56%), had household income < \$20,000 (56%), and were employed (54%). Women reported moderate

levels of neighborhood walkability (23.1 ± 4.2) and moderate levels of perceived stress (18.7 ± 6.9). Telomere length had a mean of 1.25 ± 0.23 (range 0.83-1.83). Women who reported higher levels of neighborhood walkability reported lower levels of perceived stress ($r = -.40$, $p < 0.01$) and had longer salivary telomeres ($r = .29$, $p < 0.05$). Perceived stress was not related to telomere length ($r = -.21$, $p = .097$). Maternal age was not related to neighborhood walkability, perceived stress, or telomere length.

Conclusions. Higher perceptions of neighborhood walkability were related to lower levels of stress and longer salivary telomeres among pregnant Black women. It is important to assess pregnant Black women's perceptions of their neighborhoods and stress as well as consider primary prevention strategies.

Introduction

Pregnant Black women are more likely to live in disadvantaged neighborhoods (i.e., exhibiting higher rates of vacant housing, poorer property conditions, and more litter and crime) compared with pregnant White women (Laraia et al., 2006; Messer, Kaufman, Dole, Herring, et al., 2006; Zuberi et al., 2016). Living in disadvantaged neighborhoods may increase the levels of psychological stress for these women. Indeed, research suggests that pregnant Black women living in disadvantaged neighborhoods commonly report higher levels of perceived stress (Vines, 2009; Geronimus et al., 2010; Hurd et al., 2013; Giurgescu et al., 2015). Neighborhood walkability, the extent to which a place is walkable, safe and pleasant to walk in, has also been related to psychological stress. For instance, in a sample of 798 Hispanic/Latino adults from the US, lower levels of neighborhood walkability were associated with higher levels of racial discrimination stress (Budd, Giuliani, & Kelly, 2021). In a sample of 399 postpartum African American women with ≤ 12 years of education, higher perceptions of neighborhood walkability related to lower levels of perceived stress, psychological distress and depressive symptoms (Sealy-Jefferson, 2016). However, among a sample of adults from Brazil, neighborhood walkability was not related to stress (Mendes, 2014). Similarly, in a population-based cohort aged 45 years and over from Australia, neighborhood walkability measured by administrative data was not associated with psychosocial distress after adjusting for individual-level factors (Mayne et al, 2018). Thus, research is limited of the association of neighborhood walkability with psychological stress.

Shorter telomere length (TL) has been associated with environmental stress (Theall et al., 2013). Telomeres are tandemly repeated nucleotide repeat sequences (TTAGGG) at the end of the chromosomes that are integral in genomic stability, the protection of DNA from damage, and

cellular aging (Blackburn, Epel, & Lin, 2015). The majority of papers report significantly longer (TL) in Blacks compared to Whites but also accelerated telomere shortening over time (Drury et al., 2015; Rewak et al., 2014). In a multi-racial community sample of females from Detroit, higher neighborhood satisfaction and safety were related to longer telomeres (Geronimus et al., 2015). In a representative sample of U.S. adults, respondents who lived in neighborhoods with lower aesthetic quality, safety, and social cohesion had shorter TL than those who lived in neighborhoods with a more salutary social environment, after adjustment for covariates (Needham et al., 2014). Similarly, participants from the Multi-Ethnic Study of Atherosclerosis study who reported high levels of neighborhood stress had shorter TL relative to their low neighborhood stress counterparts (Meier et al., 2019). In a study focused on African American women, overall unfavorable perception of one's neighborhood was associated with 6% shorter TL; this association was not found in African American men (Gebreab et al., 2016). Within an African American cohort, maternal perception of neighborhood disorder around their house and violent crime was associated with shorter TL of youths age 5-15 (Drury et al., 2014; Theall, Brett, Shirtcliff, Dunn, & Drury, 2013; Theall, Shirtcliff, Dismukes, Wallace, & Drury, 2017). Longer TL has been associated with higher levels of neighborhood satisfaction, quality, and safety among children and non-pregnant Black women. However, research on the association between neighborhood walkability and TL is lacking.

TL is a biological marker associated with aging and age-related diseases; its shortening is influenced by oxidative damage and replicative stress (Blackburn et al., 2015). Associations between psychological stress and TL are seen early in life. Evidence shows that Black mothers experience diminished TL in placental samples when compared to their White counterparts after controlling for maternal and infant characteristics (Jones, Gambala, Esteves et al., 2017).

Similarly, higher levels of intrauterine exposure to maternal stress have been associated with significantly lower newborn TL (Marchetto et al., 2016). The relationship carries through childhood. For instance, in a systematic review of children from 3 to 5 years of age, 11 studies found that exposure to childhood stress secondary to violence, broken families and low socioeconomic status is associated with accelerated telomere erosion (Coimbra et al., 2017). Likewise, among a large sample of African Americans (n=2,516), psychosocial stressors were associated with shorter leukocyte TL; more specifically, higher levels of cynical distrust, anger, and negative affect were associated with diminished leukocytes TL, specifically among African American women (Jordan et al., 2019). In a different study examining leukocytes TL among postmenopausal women, African American women had greater perceived stress than White women, and stress was related to shorter leukocytes TL (Jones, H. J., Janson, S. L., & Lee, K. A. 2017). Many studies have reported an association between higher levels of psychological stress and shorter. However, research has not examined the associations among neighborhood walkability, psychological stress and TL among pregnant Black women. In this pilot study, we explored the association between neighborhood walkability, perceived stress and TL among pregnant Black women.

Conceptual Framework

This study was guided by the Theory of Allostatic Load (McEwen, 2005). The theory posits that chronic cumulative exposures to stressful situations results in alterations of biological processes and ultimately increase the risk for adverse health outcomes. Chronic, cumulative stress may create disequilibrium in the body, referred to as allostatic load, which subsequently affects health outcomes. We hypothesized that cumulative exposure to neighborhoods with low levels of walkability may increase levels of perceived stress and ultimately relate to shorter TL.

Methods

Design and Sample

Data were collected as part of the Biosocial Impact on Black Births (BIBB) study. BIBB is a prospective study that examines the role of maternal factors on birth outcomes among Black women across pregnancy. This subsample of pregnant Black women (n=61) was recruited from prenatal care clinics in two metropolitan areas in the Midwest United States between January 04, 2018 and December 31, 2018. Women were enrolled in the study if they self-identified as Black or African American, were ages 18-45 years old, had singleton pregnancies, were less than 30 weeks gestation, and were able to read and write English.

Variables and Measures

Sociodemographic characteristics. Women responded to questions about socio-demographic characteristics (e.g., age, level of education, household income).

Neighborhood walkability. The Neighborhood Walkability Survey (Saelens and Sallis, 2012) is a 6-item scale that asks about perceived neighborhood satisfaction (e.g., *It is pleasant to walk in my neighborhood; I often see other people exercise in my neighborhood*) on a 5-point Likert scale (1= *strongly disagree* to 5=*strongly agree* to). The total score ranges from 6-30 with higher scores representing higher levels of neighborhood walkability. The Cronbach's alpha for this study was 0.78.

Perceived Stress. Cohen's Perceived Stress Scale (Cohen , Kamarck and Mermelstein, 1983) is a 10-item scale that that asks about feelings and thoughts during the last month (e.g., *How often have you been upset because of something that happened unexpectedly?; How often have you felt nervous and "stressed"?*) on a 5-point Likert scale (0 = *Never* 1 to 4 = *Very Often*)

with some items being reverse coded. The total score ranges from 0-40 with higher scores representing higher levels of perceived stress. The Cronbach's alpha for this study was 0.87.

Telomere length. TL was measured from saliva to ensure the highest level of women's participation. Saliva DNA TL was highly correlated with peripheral mononuclear blood cells (PMBCs) DNA TL in a study with non-pregnant adults ($r = 0.72$, $P < 0.002$) (Mitchell C et al., 2014). TL was determined concurrently using monochromic multiplex quantitative polymerase chain reaction (MMP-qPCR). Samples were performed in triplicate on duplicate plates with each sample in a different well position. Coefficients of variations (CV) were calculated to ensure uniformity of TL within a triplicate ($CV \leq 10\%$) and between plates ($CV \leq 6\%$). Final TL for each sample will be determined by the average of the triplicates on both plates. We included standardized control samples of varying lengths on all plates adding to the reproducibility and rigor of this assay. All samples were analyzed with the same standardized DNA sample to further ensure the rigor and reproducibility of the data. We measured the relative ratio between a single copy gene and the telomere repeat (T/S ratio).

Procedures

The study was approved by the Institutional Review Boards (IRB) at the two sites. The principal investigator obtained a HIPAA waiver to access medical records of women receiving prenatal care at the participating sites in order to identify potential participants. Research staff approached eligible women at 19–29-weeks gestation and invited them to participate. After obtaining informed consent, participants completed a questionnaire containing sociodemographic questions, the Neighborhood Walkability Scale, and Cohen's Perceived Stress Scale on an iPad and provided a saliva sample. Participants were also instructed to not eat, drink, smoke, chew gum, or brush their teeth prior to providing about 1-1.5 mL of saliva in a small tube. Sample was

gently shake and stored in a -80 F. Women were reimbursed a \$30 store gift card for their participation.

Data Management and Analysis

Data were entered into Qualtrics Research Suite, a web-based platform for creating online surveys. Password-protected, customer-controlled survey data were captured in real-time and stored on Qualtrics' secure and Transport Layer Security (TLS) encrypted servers.

Descriptive statistics were used to describe the sample. Pearson's *r* correlation coefficient was used to examine the associations among variables. Significance was determined at the p-value <.05.

Results

Women had a mean age of 26.5±5.8 years (range 18-40). The majority of women graduated high school or had technical/ vocational training (57%), were single (56%), had a household income < \$20,000 (56%), and were employed (54%). Women reported moderate levels of neighborhood walkability (23.1±4.2) and moderate levels of perceived stress (18.7±6.9). The TL had a mean of 1.25 ±0.23 kb (range 0.83-1.83) (see Table 1).

Table 1. Sample characteristics

Variable		
	M±SD	Range
Maternal age	26.49±5.8	18-40
Neighborhood walkability	23.10±4.2	10-30
Perceived stress	18.66±6.9	5-35
Telomere length	1.25±0.2	0.86-1.83

	N (%)	
Married or living with a partner		–
Yes	24 (39)	
No	37 (60.6)	
Employed		–
Yes	33 (54.1)	
No	28 (45.9)	
Level of education		–
< High school	9 (14.8)	
High school/ GED	29 (47.5)	
Technical/vocational training/ some college/ associate degree	23 (37.7)	
Household income		–
<\$20,000	34 (55.7)	
≥\$20,000	27 (44.3)	

Women who reported higher levels of neighborhood walkability reported lower levels of perceived stress ($r=-.40, p<.01$) and had longer salivary telomeres ($r=.29, p<.05$). Perceived stress was not related to TL ($r=-.21, p=.097$). Maternal age was not related to neighborhood walkability, perceived stress, or TL (see Table 2).

Table 2. Relationship among variables

Variable	Maternal age	Neighborhood walkability	Perceived stress
Maternal age	–	–	–
Neighborhood walkability	-.143	–	–
Perceived stress	-.062	-.400**	–
Telomere length	-.065	.288*	-.215

*p<.05, **p<.01, ***p<.001

Discussion

In the United States, Black women are more likely to live in disadvantaged neighborhoods. Living in disadvantage neighborhoods may have been related to psychological stress, which is a precursor to adverse health outcomes. Therefore, it is imperative to examine the association between neighborhood walkability, perceived stress, and biological markers such as TL.

In this study, we explored the relationships among neighborhood walkability, perceived stress, and salivary TL among pregnant Black women. We found that women who reported higher levels of neighborhood walkability reported lower levels of perceived stress and had longer TL, which aligns with the current literature. For example, in a study of 91,142 respondents, poor neighborhood walkability was associated with higher levels of psychosocial

stress after accounting for individual social and economic factors (Mayne et al., 2018). In a study with 399 postpartum African American women, lower levels of perceived neighborhood walkability related to higher levels of psychological stress (Sealy-Jefferson, 2016). Research also suggests that living in disadvantaged neighborhoods relates to shorter TL. For example, in a large sample of White and Black adults >50 years of age (n=3,869), neighborhood characteristics such as less clean neighborhoods, less safety and less social cohesion were associated with shorter TL among Blacks; neighborhood characteristics and TL were not related among the White population (Thierry, 2020). In another study with White and Black mothers, neighborhood disadvantage was associated with shorter TL among all mothers (Massey et al., 2018). Furthermore, in a large sample (n=2902) of individuals ages 18-65 years old, individuals with moderate neighborhood quality and poor neighborhood quality had an average leukocytes TL of approximately 69 and 174 base pair shorter, respectively (Park et al., 2015). Additionally, in a longitudinal study of adults (n=2,186) where neighborhood stressors were assessed at three different time points, neighborhood stressors were associated with shorter TL after accounting for social class, health behaviors, Body mass Index [BMI] and depression (Ellaway et al., 2019). No research has examined the association of neighborhood walkability with TL. We found that higher perceptions of walkability were associated with shorter TL among pregnant Black women.

In our study, perceived stress was not related to TL. Similar findings have been seen among a sample of community-recruited African American youth, in which buccal TL was not associated with the Trier Social Stressor Test for children (TSST-C), a validated psychosocial stressor for youth (Dismukes et al., 2016). However, the majority of studies report that higher levels of psychological stress are related to shorter TL. For instance, in a meta-analysis of 23

studies, increased perceived psychological stress was associated with a statistically significant decrease in TL. (Mathur et al., 2016). Similarly, in a sample of 501 primary care patients, TL was significantly shorter in patients with depression, anxiety, stress and adjustment disorders after controlling for age and sex (Wang et al., 2017). This relationship has been demonstrated among Black men as well. In a study focused on African American midlife men, higher levels of financial stress were associated with diminished LTL (Schrock et al., 2018). We did not find an association between perceived stress and TL potentially due to small sample size.

This study has few limitations. First, this study had a small sample size. Future studies need to include larger samples of pregnant Black women. Secondly, while the cross-sectional design allows for analysis of associations among variables, we are unable to analyze the process of telomere shortening from a single time point. Future research needs to measure neighborhood walkability, psychological stress and TL at multiple time points across the lifespan. Thirdly, the cross-sectional design of the study does not allow for causal relationships. Finally, both the walkability and perceived stress scales are self-reported scales. Therefore, future work would benefit from studying the association between neighborhood walkability, perceived stress and TL among a larger sample across a longer period of time.

In our study, Black women who reported lower levels of neighborhood walkability also reported higher levels of perceived stress and shorter TL. In a study conducted in Belgium, individuals living in highly walkable neighborhoods (i.e. residential density, street connectivity, land use mix) were more likely to walk for active transportation and walk for leisure compared with individuals living in less walkable neighborhoods (77% and 28%, respectively) (Sunbquist et al, 2011). Walking has been related to lower levels of stress (Ren and Kwon, 2021) and longer TL (Tucker, 2020). Therefore, advocating for sidewalks, parks and green spaces in the

neighborhoods where residents can walk safely may improve their psychological wellbeing and slow down the process of TL shortening. Maternal-child nurses should assess neighborhood walkability among pregnant Black women. Resources of spaces where women could walk (e.g. a park) should be provided. Early identification of disadvantaged neighborhoods coupled with proactive actions to increase neighborhood walkability may reduce perceived stress and telomere shortening, consequently decreasing adverse health outcomes. Improving neighborhood walkability could be key to improving health outcomes among pregnant Black women.

Conclusion

To our knowledge, this is the first study suggesting that higher perceptions of neighborhood walkability are related to lower levels of perceived stress and longer salivary telomeres among pregnant Black women. Future research should contribute to identifying effective methods of increasing neighborhood walkability with the goal of attaining lower perceived stress and slower decline in TL.

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