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# Understanding Embodiment in Place-Health Research: Approaches, Limitations, and Opportunities

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**Abstract** Research on how place affects health continues to grow. Within the place-health research field, there is increasing focus on how place becomes embodied—i.e., how place-based social and environmental experiences and exposures “get under our skin” to affect physiological functioning and health. While much has been learned, currently favored place-embodiment research approaches present limitations that inhibit continued gains in understanding. This article presents a brief summary of place-health literature related to place-embodiment, highlighting common approaches. Core limitations are then discussed with an eye towards improving research going forward, highlighting mixed-method, spatially dynamic, and participatory intergenerational approaches as promising considerations.

**Keywords** Neighborhoods and health · Place and health · Embodiment · Biometrics · Allostatic load · Intergenerational research · Qualitative methods · Participatory research

## Introduction

Understanding how “place” affects health is a prominent concern within public health. Generally, notions of

place encompass the social, physical, and economic contexts of—and interactions we have within—our daily community environments, as well as the social and political processes through which these environments are produced and represented. This work, commonly referred to as *place-health* research, has grown rapidly over the last 15 years [1–4]. However, major conceptual and methodological challenges remain in defining “place” [5–10], and characterizing and measuring place contexts [11–21]. One area of place-health research that is especially beholden to these challenges is the biological embodiment of place and how it affects health and well-being over time. Much of this work at the population level entails the collection and spatial analysis (e.g., neighborhood-level) of biometrics (e.g., diurnal cortisol, C-reactive protein, telomere length) in relation to what are considered core social determinants of health, such as socioeconomic status (SES). This work certainly invites us to probe deeper into the notion of the embodiment of place. However, if the ultimate goal is to correctly specify the processes and mechanisms through which “place” becomes biologically incorporated over time, it is of paramount importance that pertinent and specific physical and social exposures/experiences, and their corresponding spatial locations (i.e., of individual exposures) and geographic distributions (i.e., overall spatial patterns in relation to population characteristics), are elucidated and accounted for. Moreover, given the cumulative and dynamic nature of embodiment [22–25], considerations of life stage and life course perspectives are critical in optimizing our ability to appropriately gauge experiences and exposures that

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might vary over time and/or be generationally- or life stage-contingent (e.g., age-related differences in the perception and appraisal of social/physical environments).

With these considerations in mind, this paper has three interrelated objectives. First, this paper provides an overview of some of the conceptual roots for “embodiment” within public health research. Second, this paper provides a brief summary of place-health literature related specifically to the “embodiment of place”, highlighting common approaches in a selection of illustrative studies reflecting these conceptual roots. Here, our goal is not an exhaustive integration and analysis, but rather a scoping inquiry and appraisal to center and invigorate discourse in this area. Lastly, core limitations are discussed with an eye towards improving place-health embodiment research going forward, highlighting mixed-method, spatially dynamic, and participatory intergenerational approaches as promising considerations.

### Embodiment: Some Roots and Conceptual Groundings

“Bodies tell stories about—and cannot be studied divorced from—the conditions of our existence.” [22]

In public health, perhaps the most developed and useful conception of embodiment is that articulated by Krieger [22, 26]. As a foundational construct of ecosocial theory [27], *embodiment* is understood as the process through which the outside physical and social world becomes embedded into our biology—that is, how daily interactions with our social and physical environments “get under our skin” to affect our physical, psychological, and emotional well-being by altering how our body functions [22]. The general idea is that we encounter, perceive, interpret, and incorporate an endless array of social and physical environmental experiences and exposures that shape our physiologic functioning on a day-to-day basis, whether such incorporation be biologically and/or chemically direct (e.g., air pollution, roach antigens), or psychosocially mediated (e.g. experience of discrimination, exposure to community violence, perception of threat). Thus, in the same moment, we might simultaneously incorporate the air around us just as we incorporate the conversation *about* us, and might do so consciously or unconsciously.

Embodiment, then, is both continuous and dynamic, as well as both objective and subjective. Our bodies keep tally of our lived experiences—our physical and social encounters—and the health and well-being of our bodies can accordingly bear witness to the contexts and conditions of such experiences and encounters. Moreover, these contexts and conditions of embodiment are shaped and organized by societal arrangements of power, privilege, and opportunity—both current and historic. The processes and mechanisms of embodiment—the so called *pathways of embodiment* [22], forged through an interplay of our inner biology and the outer social world—are beholden to and an expression of such social, economic, and political arrangements. Inequalities in health across populations, then, present as “embodied expressions of social inequality” [28]. “Reading” bodies as texts can accordingly offer clues for discerning, and provide insight into, the matrix of structural factors that underlie and drive patterns of population health and illness.

As Krieger and Davey Smith [29] articulate, embodiment “invites us to consider how our bodies, each and every day, accumulate and integrate experiences and exposures structured by diverse yet commingled aspects of social position and inequality.” How such accumulation and integration occurs can in part be understood through engaging two distinct yet related concepts that represent manifestations/mechanisms of embodiment: “weathering” [30] and allostatic load [31–33]. Developed to help explain inequalities in black-white birth outcomes and mortality, the *weathering hypothesis* posits that populations subjected to the chronic stress of racial discrimination, including social and economic adversity and political marginalization, experience an early breakdown and dysregulation of physiologic systems which leads to a deterioration of health [30, 34]. As originally conceptualized, weathering thus describes a potential process underlying premature aging [35, 36]. Weathering can accordingly be understood as a physiological consequence of social inequality—the embodiment of a society predicated upon and patterned by inequalities of power, privilege, and opportunity. Those with a less favorable arrangement must endure the storm, and their bodies tell a corresponding story—weathered by their biological incorporation of social inequality.

Related to weathering, and in many ways an underlying process through which it operates, is the concept of *allostatic load* [31, 37]. Allostatic load refers to the long-term effect of physiologic responses to stress—the

strain imposed upon and cumulative wear and tear of the body resultant from stress responses to “repeated or chronic environmental challenge” [31]. Allostatic load is based on the notion of allostasis, understood as the body’s normal short-term adaptive response to environmental stimuli—a process of “maintaining stability through change” [38]. Unlike the notion of homeostasis wherein physiologic systems are understood to operate at optimal set-points (e.g., body temperature), allostasis “emphasizes the idea of optimal operating ranges of physiologic systems”, which has been described as adaptive plasticity [24]. Allostatic systems are fluid and responsive to environmental demands, enabling the body to adapt to and cope with short-term physical and psychological challenges. The classic example is the “fight or flight or freeze” response, wherein short-term alterations in multiple physiologic systems (e.g. those regulating heart and respiratory rate), enable us to physically respond to situations we appraise as dangerous or threatening. These short-term alterations are necessary for optimal physiological functioning—they are normal. Over time, these normal allostatic responses can become dysregulated (e.g., too frequent, excessive, maladaptive stress response), the consequence of which is allostatic load—essentially, allostasis gone wrong.

Allostatic load, then, can be understood as the physical embodiment of repeated or chronic exposure to stress-inducing social and living conditions over time—a physiologic expression of weathering. Given the cumulative nature of allostatic load and weathering processes, and as alluded to by Krieger [22], embodiment accordingly must be understood within a life course perspective, and there is a growing body of work aimed at revealing how the outside world gets “under our skin” over time and over the course of our lives [39–49]. Engaging the interplay and overlap of these concepts—weathering and allostatic load—offers guidance to aid our understanding of how our daily encounters with the world around us can influence our health and well-being. And with this understanding we can begin to explore notions of embodiment in relation to “place”, and how the places in which we live, learn, work, play, and age leave their marks on and inside of our bodies.

### **Embodiment in Place-Health Research: Approaches**

Our physiologic functioning and overall health are perpetually influenced by and cannot be separated from the

lived realities and contexts of our daily lives—lives that unfold in particular locales and time periods. Thus, the story of embodiment is in many ways a story about place—what it is, when it is, where it is, how it is, and for whom. Telling this story about the embodiment of place has been the focus of an increasing amount of place-health research in recent years. Much of this place-embodiment work at the population level entails the collection and spatial analysis of biometrics in light of what are considered core social determinants of health, e.g., neighborhood SES. Generally, this work can be categorized based on whether cross-sectional or longitudinal approaches are taken, whether samples are adults or youth, and whether a cumulative measure of “embodiment”, i.e., multi-component assessments of cumulative biological risk or allostatic load, or a singular biometric component is explored (e.g., diurnal cortisol).

In regard to longitudinal approaches, Gustafsson and colleagues [25], for example, examined whether cumulative neighborhood disadvantage—based on residential census area data—measured over four time points between ages 16 and 43 was associated with allostatic load (AL) at age 43. Their measure of AL was based on 12 biomarkers, with cardiac, metabolic, neuroendocrine, and inflammatory metrics. They found that cumulative neighborhood disadvantage was associated with higher AL in the total sample and for men, but not among women. Similarly, Nazmi and colleagues [50] examined longitudinal associations between neighborhood context and changes in IL-6 over a 3–4-year period among adults. Here, neighborhood “context” consisted of census- and survey-based measures of “deprivation,” “problems,” “safety,” and “social cohesion”. Their results showed that higher levels of deprivation and problems, and lower levels of perceived safety, were associated with increases in IL-6 levels.

Most findings to date, however, are based on cross-sectional approaches. For example, in the same Nazmi and colleagues study [50], cross-sectional analyses revealed that deprivation, safety, and problems remained significantly associated with fibrinogen after adjustment, and IL-6 remained associated with safety and problems. In another study related to place and inflammatory markers among adults, Petersen and colleagues [51] examined associations between neighborhood SES (based on residential census tracts) and inflammatory biomarkers, C-reactive protein (CRP) and IL-6, finding that neighborhood SES was inversely associated

inflammation. A similar study among youth ages 5–18 by Broyles and colleagues [52] examined associations between neighborhood poverty and crime (again based on residential census tracts) and fasting serum CRP levels, revealing that children living in neighborhoods with high levels of poverty or crime had elevated CRP levels compared to children from low poverty and low crime neighborhoods.

Another line of cross-sectional work has explored associations between measures of place contexts and cortisol patterns. For example, Barrington and colleagues [53] examined stress as an explanatory mechanism for the relationship between neighborhood deprivation and health. They tested associations between measures of individual perceptions of neighborhood “social control” and “fear of crime” (based on residential census tracts), and cortisol reactivity to a stress test among adults. Their findings revealed that while neighborhood deprivation was significantly associated with both social control and fear of crime, it was only associated with women’s cortisol reactivity. They also found that social control, but not fear of crime, was significantly positively associated with cortisol reactivity, with analyses suggesting it mediated the association between neighborhood deprivation and cortisol reactivity among women. In a similar study among adults, Karb and colleagues [54] examined the association between neighborhood stressors (again based on residential census tracts) and diurnal cortisol patterns. Findings revealed that those residing in neighborhoods with high levels of perceived or observed stressors exhibited greater cortisol dysregulation (e.g., flatter/slower decline), and that mean cortisol levels were lower for those in neighborhoods with higher neighborhood stressor levels and lower levels of social support (a combination of findings suggesting dysregulation due to chronic stress). Do and colleagues [55] demonstrated similar findings among adults in their examination of neighborhood context (poverty, violence, disorder, and social cohesion based on census tract and survey-based data) and circadian cortisol levels, as did Roe and colleagues [56] in their examination of neighborhood greenspace (based on residential census tract) and diurnal cortisol patterns. Results similar to these have also been observed in studies focused on youth [57–59].

Cross-sectional approaches have also been popular in exploring associations between place contexts and more cumulative measures embodiment, i.e., allostatic load (AL) and cumulative biological risk (CBR). For example,

Bird and colleagues [60] examined whether neighborhood SES, based on residential census tract data, was associated with disparities in AL, measured as an aggregate index with metabolic (e.g., HDL cholesterol), cardiac (e.g., systolic blood pressure), and inflammatory (e.g., CRP) biomarkers among adults. They found that living in a lower SES neighborhood was associated with worse AL, independent of individual SES measures. Similarly, Merkin and colleagues [61] examined race-specific patterns of associations between neighborhood SES (again based on residential census tract), and AL based on 9 biometrics (serum levels of CRP, albumin, glycated hemoglobin, total and HDL cholesterol, waist-to-hip ratio, systolic and diastolic blood pressure, and resting heart rate). They found a significant inverse (negative) association between neighborhood SES and AL for Blacks, with weaker and non-significant inverse associations for Mexican Americans and whites after adjustment, respectively. Schulz and colleagues [62] corroborate these findings in their study of associations between neighborhood poverty (based on residential census tracts), and AL based on 8 biometrics (systolic and diastolic blood pressure; blood glucose; waist circumference; HDL and total cholesterol; fasting triglycerides). They found that neighborhood poverty was significantly positively associated with higher levels of AL, with analyses suggesting this association was mediated by self-reports of neighborhood environmental stress. King and colleagues [63] observed similar results in their examination of associations between measures of neighborhood context (“neighborhood socioeconomic disadvantage” and “neighborhood affluence”) based on census tract boundaries, and cumulative biological risk (CBR) measured using 8 biometrics (systolic and diastolic blood pressure; resting heart rate; hemoglobin A1c; C-reactive protein; waist circumference; total and HDL cholesterol). Here, neighborhood affluence predicted lower levels of CBR, but neighborhood socioeconomic disadvantage did not. Mair and colleagues [64] demonstrated similar associations among adults, while work by Theall and colleagues [65] and Brody and colleagues [66] has revealed that these associations also exist among youth.

Lastly, cross-sectional approaches have been used to investigate associations between measures of place and biological aging, specifically telomere length. For example, a recent study by Massey and colleagues [67] found that a cumulative measure of neighborhood disadvantage (e.g., poverty, unemployment, welfare receipt) based on residential census tract data was significantly associated

with shorter telomere length among both black and white women. Earlier work by Needham and colleagues [68] also examined relationships between neighborhood socioeconomic disadvantage and social environment (“neighborhood” again defined by residential census tract) and leukocyte telomere length (LTL) in an adult sample from the Multi-Ethnic Study of Atherosclerosis, finding that lower quality neighborhood social environment (e.g., safety, esthetic quality, social cohesion) was associated with shorter telomeres. Likewise, among a sample of Dutch adults, Park and colleagues [69] found that perceived neighborhood quality (e.g., fear of crime, noise) was associated with shorter LTL among respondents reporting moderate and poor neighborhood quality. In another study based on respondent neighborhood perceptions, Gebreab and colleagues [70] found that neighborhood problems and unfavorable neighborhood conditions (e.g., noise, violence, unmaintained sidewalks) were significantly associated with shorter LTL among African American women, but not men. Theall and colleagues [71] demonstrated relationships between similar neighborhood measures and telomere length among black youth. Additional work focused on black youth revealed associations between telomere length and neighborhood violence (including domestic violence) and liquor retail density, this time using geographic buffers to define “neighborhood” (i.e., instead of residential census tracts) [72].

Overall, this growing body of place-embodiment research draws clear connections between measures of place and measures of physiological dysfunction. It also suggests potential mechanisms through which place experiences and exposures become biologically embedded (e.g., stress and inflammatory response pathways) and reveals important sex-based differences in associations between measures of place contexts and biomarkers that should encourage and inform additional research [25, 53, 56, 57, 64, 70]. While work to date appears to be largely cross-sectional, it has done well to suggest a range of place factors (e.g., perceptions of safety, crime, noise, green space) implicated in place-embodiment processes and offers some useful direction for future inquiry.

### **Embodiment in Place-Health Research: Limitations as Opportunities**

The current body of work does well to evince place-embodiment as a phenomenon and encourage further

elucidation of relevant experiences/exposures, as well as explication of processes through which they become embodied. Yet as with any growing area of inquiry, there are some fundamental challenges and limitations that warrant thorough consideration going forward.

First, as is the case with much place-health research in general, place-embodiment work to date has relied heavily on non-participatory, quantitative approaches to tell the story of place, using survey-based methods with collection of biometrics. Thus, peoples’ bodies have “spoken” *about* them *without* them—that is, study participants have not been afforded opportunities to speak on behalf of their own bodies beyond responses to predetermined survey items. Yet researchers are using study participants’ bodies (i.e., their biospecimens) to tell stories about them as people—the bounds and plots of which have been preemptively delimited by methodological and procedural choices.

Highlighting this tension is not necessarily to question the strengths of this form and line of survey- and biometric-oriented work, or to challenge the value of related findings. It is, however, to suggest that the stories of place-embodiment currently being told are incomplete, and indeed might be enhanced (i.e., more nuanced, more relevant, more actionable) with qualitative and participatory approaches that afford people opportunities to speak about their place-embodiment themselves—a more inclusive (re)presentation of the place-embodiment narrative with both quantitative and qualitative chapters integrated along the way. Qualitative and mixed-methods approaches, particularly those with a community-based participatory research (CBPR) orientation [73–75], can allow for a more nuanced and grounded rendition of the place-embodiment landscape by eliciting people’s lived and embodied expertise regarding place-based experiences and exposures. In the context of place, place-embodiment, and health, local/regional laws, policies, and social norms that shape spatial dimensions of social determinants represent discernable and actionable “pathways of embodiment” and thus opportunities to intervene. As such, CBPR, and other similar collaborative and participatory approaches that are locally focused, action-oriented, and equitably include community residents as co-researchers, represent a promising way to address limitations discussed here. These sorts of collaborative endeavors can more completely unpack the ways in which local place contexts are experienced and embodied on a daily basis, as well as afford guidance in identifying the political and



social processes that might be implicated in residents' embodiment experiences. Adopting participatory mixed-methods approaches (see for example, Dennis and colleagues [76] and Richardson and Nuru-Jeter [77]) can help re-contextualize place and the embodiment of place by putting people back into their bodies and allowing them—the study participants—to contribute more fully to the knowledge creation process. This in turn can more readily facilitate knowledge translation and action that is timely and responsive to the social and political realities of people's daily place contexts, thus moving place-embodiment research beyond abstract and de-placed associations whose value and utility stem primarily from generalizability, not actionability.

Second, it seems operational definitions of “place” in this body of work are based largely on administrative boundaries (e.g., census tracts), and only the administrative boundary of residence. This of course fails to capture the complete place-embodiment experience, ignoring the everyday lived reality of peoples' “spatially polygamous” lives as they move to and through spaces and places far beyond the area surrounding their residence [21, 78]. A growing body of literature has made clear that efforts to unpack the relationships between place, people, and people's health must be able to account for their multi-nodal, time-variant, and spatially-specific place experiences [5, 10, 15, 18, 20]. This means engaging “relational” and dynamic notions of place that are defined not by arbitrary administrative lines, but by lived spatial realities and patterns of mobility [7]. Furthermore, within the administrative boundary approach, much work to date falls short in revealing what it is specifically (e.g., beyond proxy measures like SES) that matters for place-embodiment processes, and *where* that “what” is specifically located and experienced spatially. In other words, within current approaches, “place” itself is non-specific, often arbitrarily bound, and it is not always clear *what* is being embodied, nor when or where. Place-embodiment research will be enhanced greatly through design and methodological approaches that prioritize and can accommodate not only more nuanced and dynamic operational definitions of “place”, e.g., multiple spatial locations within an activity space [79–81], but also greater specificity regarding *which* place-based experiences and exposures are most salient and thus most germane to place-embodiment. Recent place-health work suggests that participatory, mixed-method, and GIS-based approaches could prove particularly valuable on this front [76,

82–85]. Such approaches have not only afforded participants the opportunity to actively contribute to research processes, but allowed for more dynamic, spatially specific, and contextualized explorations of place through incorporation of non-survey-based methods that capture actual spatial activity patterns and experiences—all of which can add value to place-embodiment research.

Third, place-embodiment work to date has sparingly focused on or directly involved youth. This means that the current story of place-embodiment is based largely on an adult's perspective (and body), which accordingly limits our ability to appropriately situate, gauge, and delineate the role(s) of age, generation, and timing in place-embodiment over the lifecourse. As with place-health research in general, both objective and subjective (i.e., perceived) measures of place matter [53, 69, 70, 86–92]. On the most basic level, adults and youth encounter and experience drastically different places and place contexts on a day-to-day basis. Appraisals of and responses to these experiences are inextricably linked to age and life-stage—a 50-year-old will see, interpret, process, and react to aspects of place contexts (e.g. community violence, segregation) differently than a 15-year-old. Furthermore, the 50-year-old “version” of an individual will perceive and respond to their place-based experiences and exposures differently than their 15-year-old self. Ultimately, a lack of progress in this area will inhibit our ability to correctly specify mechanisms of place-embodiment over time and, consequently, our ability to identify, design, and time appropriate interventions for optimal effect. Again, given the cumulative and dynamic nature of embodiment [22, 25, 46, 50, 93], the dynamic and relational nature of place [7, 21, 81, 94], and the age- and life-stage contingency of place-embodiment exposures and perceptions/appraisals thereof [23, 39, 58, 95], it is critical that future work explores and accounts for experiential and perceptual differences that may be life-stage and/or generation-contingent. Growing the field to encompass more inter-generational and longitudinal approaches could prove fruitful here (i.e., actively involving youth), in addition to further exploring any existing data sources that capture potential youth place-embodiment experiences (e.g., Fragile Families and Child Wellbeing Study).

Fourth, and in aggregate, current approaches to place-embodiment research tend to decontextualize the embodiment experience, losing sight of and leaving out details related to the lived reality of everyday social, political, environmental, and economic conditions that

are experienced. The goal of conducting place-embodiment research, ostensibly, is to identify a set of spatially organized exposures and/or patterns of experiences that exert some form of positive or negative health effect through altering the physiologic functioning of those who encounter or share such exposures/experiences. The motivation, presumably, is to intervene and take action to mitigate the negative and enhance the positive. But much work completed thus far has lacked specificity in regard to what place is (to those embodying it), which attributes of place matter, where these attributes are spatially located, when these attributes are experienced/encountered, and the underlying structural factors, e.g. laws, policies, systems of social exclusion, that determine the spatial distributions of these attributes in relation to population patterns. Nor has existing work engaged study samples as *full people*—as constituents with political voice, networked social power, and agency. As such, approaches to date cannot tell the full story of embodiment and accordingly offer limited direction in regard to intervention and action—such de-placed, de-politicized, and ironically disembodied accounts of place-embodiment are insufficient. As articulated by Krieger [22], embodiment and *pathways of embodiment* should be understood in light of and cannot be divorced from notions of *agency and accountability*. We should accordingly ask ourselves if the methodological and procedural choices we make enhance and facilitate community agency, or preclude and mask it. An approach to place-embodiment research that puts people back in their bodies—facilitating and enhancing their agency—can more thoroughly tell the story of embodiment and provide a more complete rendition of the place, embodiment, and health picture. As suggested above, centering this work within CBPR offers promise to proceed in a way that values residents' lived experience and respects their "expertise" of/with their own embodiment histories. In this way, the story of place embodiment can be a co-authorship between community and academic experts that aims to co-create, co-produce, and integrate various forms of knowledge and expertise regarding place and how it "gets under our skin".

## Conclusion

The aim of this paper was to provide an overview of place-embodiment research within public health,

highlight potential limitations facing the field, and suggest opportunities to improve research efforts going forward. As the place-health research field continues to grow, so does understanding of the importance of a life course approach. Similarly, community-driven and participatory approaches like CBPR have gained marked traction and are seen as indispensable in research and intervention efforts. And as more and more localities move towards place-based strategies to address health inequities, it is increasingly important to ensure that such strategies are rooted in inclusive, nuanced, and lived understandings of locally/regionally experienced place contexts. Efforts to improve our understanding of how such contexts become embodied, as well as the factors that shape risk and opportunity within these contexts, could benefit greatly from diversifying conceptual, methodological, and procedural approaches. In essence, the story of place-embodiment will be richer and more impactful with some fundamental improvements to directorship, character development, and narration. For place-embodiment research this means evolving to include mixed-method, participatory, spatially and temporally dynamic, and intergenerational approaches that listen to what *people* say, in addition to what their bodies say.

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