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ORIGINAL RESEARCH

Physical Activity in the Summer Heat: How Hot Weather Moderates the Relationship Between Built Environment Features and Outdoor Physical Activity of Adults

Kevin Lanza, Brian Stone Jr, Paul M. Chakalian, Carina J. Gronlund, David M. Hondula, Larissa Larsen, Evan Mallen, and Regine Haardörfer

Background: Research has not yet examined how hot weather moderates the relationship between the built environment and outdoor physical activity levels. The authors posited that hot days will increase the magnitude of the expected directional effect of built environment features on physical activity. **Methods**: This longitudinal study included 134 US adults from the Three city Heat and Electrical failure AdapTation study. Adults self-reported physical activity for multiple summer days ($n_{\text{study-days}} = 742$) in 2016. Hot days were defined as ≥90th percentile of daily maximum heat index. Built environment features included density, safety, trees, hilliness, connectivity, access to parks, and access to shops + services. Separate growth curve models with interaction terms (ie, hot day × built environment feature) were run for daily minutes of outdoor physical activity (ie, any activity and recommended activity). **Results**: Neither hot days nor built environment features impacted outdoor physical activity significantly, and hot days did not moderate the relationship between built environment features and physical activity ($P > .05$). **Conclusions**: With adults failing to modify behavior on hot days, cities may be placing adults at increased risk of exertional heat illness. The authors recommend incorporating the risk of exertional heat illness in health impact assessments and deploying heat management strategies.

Keywords: health determinants, public health practice, temperature, urban climate, heat management strategies

The United States is in the midst of a physical inactivity problem, where only 54.1% of adults self-reported reaching levels of aerobic physical activity recommended by the 2008 Physical Activity Guidelines for Americans in 2017.[1] This lack of physical activity, along with poor eating habits, results in an estimated 300,000 US deaths per year.[2] Furthermore, individuals who forgo physical activity are unable to reap the mental health benefits attributed to physical activity.[3] Physical inactivity is an economic burden for the United States, with medical costs for obese individuals averaging $1429 more per year than those of other individuals.[4]

To learn how proposed plans, policies, or projects impact physical activity, public health practitioners administer health impact assessments (HIAs). Researchers can inform HIAs by investigating which factors associate with physical activity, and do so by adopting theories of health behavior such as the ecological model.[5] The ecological model recognizes there are multiple influences across multiple levels on specific health behaviors, and these influences on behaviors interact across these different levels (Figure 1). Considering all determinants results in multilevel interventions that have a higher likelihood of changing behavior.[6]

Behavior setting, also known as the built environment, is an environmental level within the ecological model.[7,8] Behavior settings represent the places where physical activity may occur and access to these places. Research efforts have uncovered significant associations between several built environment features and physical activity. Among characteristics of the built environment, residential density and vegetation have been found to exhibit positive associations with physical activity,[9,10] crime has been found to exhibit a negative association,[11] and hilliness has been found to exhibit a mixed association.[12,13] Regarding access to behavior settings, road connectivity and access to shops and services have been found to exhibit positive associations with physical activity,[14,15] while park access and physical activity exhibit a mixed association.[16]

Within both the natural environment and behavior settings levels of the ecological model, weather is another factor that has garnered the attention of physical activity researchers. Specifically, temperature has been found to modify human behavior, with a systematic review showing leisure-time physical activity increases in summer over winter months.[17] Although the majority of studies assessing the temperature–physical activity relationship find a positive association between temperature and physical activity,[18–20] the few studies taking place in warm climates reveal an inverse association.[21,22]

While past physical activity research has separately investigated the associations with both built environment features and temperature, no studies (1) examine the interaction between built environment features and temperature on physical activity or (2) focus on exceptionally hot summer days. This work responds to the question: Do hot days moderate the relationship between

Lanza is with the Michael & Susan Dell Center for Healthy Living, School of Public Health, The University of Texas Health Science Center at Houston (UTHealth), Austin, TX. Stone and Mallen are with the School of City and Regional Planning, Georgia Institute of Technology, Atlanta, GA. Chakalian is with the School of Human Evolution and Social Change, Arizona State University, Tempe, AZ. Gronlund is with the Institute for Social Research, University of Michigan, Ann Arbor, MI. Hondula is with the School of Geographical Sciences & Urban Planning, Arizona State University, Tempe, AZ. Larsen is with the A. Alfred Taubman College of Architecture and Urban Planning, University of Michigan, Ann Arbor, MI. Haardörfer is with the Rollins School of Public Health, Emory University, Atlanta, GA. Lanza (kevin.l.lanza@uth.tmc.edu) is corresponding author.

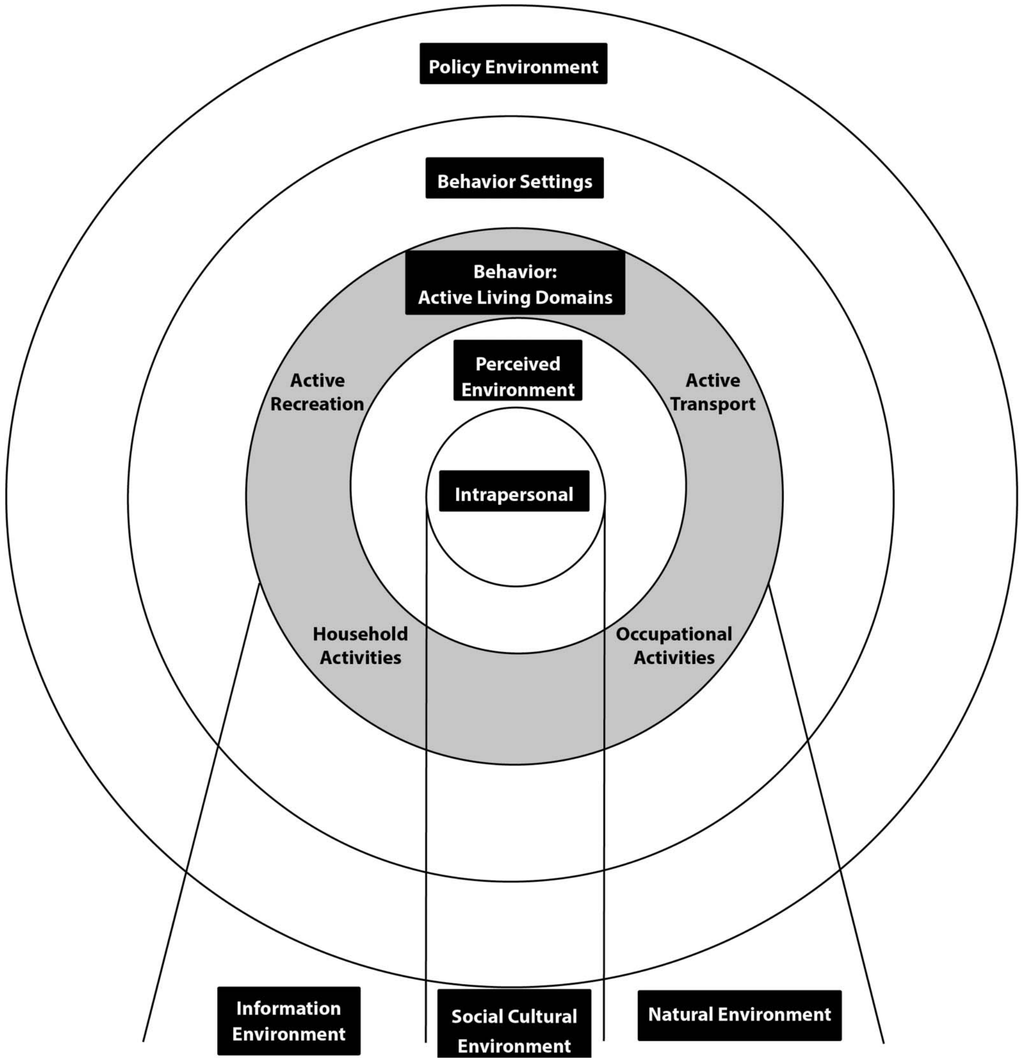

Figure 1 — Ecological model of 4 domains of active living.[5]

built environment features and outdoor physical activity levels of adults?

The overarching hypothesis is that hot days will increase the magnitude of the expected directional effect of all built environment features on outdoor physical activity levels. With few individuals shown to frequent outdoor spaces in hot and humid conditions due to thermal discomfort,[23] we posit that heat stress will cause individuals to become more sensitive to the impact of built environment features on their physical activity behavior. For example, if tree canopy exhibits a positive association with physical activity, then on hot days, tree canopy will exhibit a more positive association with physical activity, as individuals will further seek out relatively cool, canopied areas as protection from thermally uncomfortable conditions. Conversely, if individuals avoid hilly routes when active commuting to work, then on hot days, individuals will have a heightened sensitivity to hills as a barrier to active commuting due to the combination of physiological stress from heat and hills. Study results can help researchers better understand how the combination of weather and development decisions impact physical activity, and inform HIAs as to whether proposed plans, projects, or policies affect physical activity and near-surface temperature conditions.

Methods

Sample Selection

The sample for this longitudinal study originated from the Three city Heat and Electrical failure AdapTation (3HEAT) study (National Science Foundation, grant number 1520803). The 3HEAT study aimed to estimate (1) how behavioral, environmental, and technological changes mitigate the health impact of extreme heat in Atlanta, GA; Detroit, MI; and Phoenix, AZ; and (2) the human health risk of power outages during periods of extreme heat. Atlanta, Detroit, and Phoenix were selected as study cities for their representation of different US climate regions and proximity to the 3HEAT research teams of Georgia Institute of Technology, University of Michigan, and Arizona State University, respectively. The research teams recruited ~50 individuals per city through nonrandom sampling, with the goal of capturing a spatial mix of adults that resembled the city's demographic composition. Prior to undertaking any study activities, research teams at the Georgia Institute of Technology, University of Michigan, and Arizona State University were granted institutional approval of study protocols and obtained informed consent from all study participants. From July to September 2016, researchers asked study participants to complete at least 6 study days, with eligible study days identified as those forecasted to be comparably hotter than others throughout the summer.

Physical Activity Measurement

The 3HEAT collected the physical activity data used in this work through time activity diaries—24-hour, continuous, self-reported, written records detailing the length of time spent at a location and the physical activity intensity level(s) at that location—completed by study participants on study days. Time activity diary forms comprised 4 options for physical activity intensity level: 1 = sitting/lying down, 2 = light exertion, 3 = moderate exertion, and 4 = heavy exertion. Two versions of the dependent variable were included in this work: (1) any activity = daily minutes of any outdoor physical activity during waking hours and (2) recommended activity = daily minutes of recommended outdoor physical activity during waking hours. Any activity defines physical activity as intensity levels 2 to 4, while recommended activity measures physical activity as levels 3 to 4. Both versions were log transformed in final models so the distributions of residuals would be normal.

Heat Measurement

Hourly air temperature and dew point data (May–September 2000–2016) from the weather station at each city's major airport (ie, Hartsfield–Jackson Atlanta International Airport, Detroit Metropolitan Wayne County Airport, and Phoenix Sky Harbor International Airport) were downloaded online from the Integrated Surface Database maintained by the National Climatic Data Center.[24] Heat index (ie, a combination term for air temperature and relative humidity) was computed from these data to develop the variable for hot day, defined as any day where heat index was ≥90th percentile of daily maximum heat index during the warm season (May–September) from 2000 to 2016. The 90th percentile values for Atlanta, Detroit, and Phoenix were 96.7°F, 91.5°F, and 109.3°F, respectively.

Built Environment Measurement

This study examined 7 built environment features known to have statistically significant associations with physical activity: (1) density, (2) safety, (3) trees, (4) hilliness, (5) connectivity, (6) access to parks, and (7) access to shops + services. All built environment variables, except safety, were analyzed within ArcGIS (version 10.5.1; Esri, Redlands, CA) and assessed within an 800 m radius from a participant's home address. The literature commonly adopts a distance from a location to capture the local environment in which an individual may pursue a significant portion of physical activity, with 800 m equating to a 10-minute walk.[25]

Density. As a proxy for population density, mean census block size was calculated within a geographic information system (GIS) from TIGER/Line Shapefiles (2016),[26] with an inverse relationship between block size and density.

Safety. Safety data originated from a screening survey administered to all 3HEAT participants in June 2016. The survey item asked, "How safe or unsafe do you feel in your neighborhood: very unsafe, somewhat unsafe, somewhat safe, or very safe?"

Trees. Trees were measured as tree canopy percentage from aerial imagery (1-meter, 4-band raster images) provided by the National Agriculture Imagery Program.[27] The images were captured during the agricultural growing season—the period of peak vegetative health that matches the conditions of study days—in 2015, 2014, and 2013 for Atlanta, Detroit, and Phoenix, respectively. In ERDAS IMAGINE 2016 (Hexagon Geospatial, Madison, AL), unsupervised classification was performed using k-means clustering to categorize pixels into 100 unique classes, which were then reclassified within GIS into either (0) nontree or (1) tree. Zonal statistics were employed to calculate the percentage of tree canopy per census tract.

Hilliness. Hilliness was measured as the mean slope of the ground in degrees (ie, 0° = flat surface and 90° = completely vertical surface) within 800 m of participants' home addresses using 1/3 arc-second digital elevation models provided by the National Elevation Dataset (2017) for the 3 cities[28] and the ArcGIS Slope and Zonal Statistics tools.

Connectivity. To develop the variable for connectivity—defined as the ability to access different destinations and measured as the number of road intersections in an area—this study made use of TIGER/Line Shapefiles (2016) of all roads for the counties affiliated with Atlanta, Detroit, and Phoenix.[29] Within GIS, the number of walkable road intersections was counted.

Access to Parks. Access to parks measured public park acreage, using separate park shapefiles for each city from 2018.[30–33] After trimming the shapefiles to only public parks, 800 m Euclidean buffers were used to clip parks.

Access to Shops + Services. Access to shops + services measured the number of commercial properties by utilizing parcel shapefiles for each study city.[34–36] Detroit data were from 2015, and Atlanta and Phoenix data were from 2018. Property use codes included within the parcel shapefiles were used to identify and count commercial properties.

Statistical Analyses

To understand how hot days may moderate the relationship between built environment features and outdoor physical activity of adults, this study utilized 2-level growth curve models or linear mixed-effects models.[37] Multilevel modeling was selected because each study participant reported physical activity levels across multiple study days, leading to statistical dependency and heteroskedasticity. The 2 model levels were (1) study day and (2) study individual. All statistical analyses were performed in SPSS (version 24; IBM, Armonk, NY).

Final growth curve models controlled for factors that previous studies have shown to significantly associate with physical activity: sex, race, age, health status, income, city, rain, and weekends.[4,38–40] This analysis included a succession of 4 growth curve models: Model 1 was the unconditional growth model with dependent variable, time indicator variable, and intercepts; model 2 added hot day, rainy day, density, safety, trees, hilliness, connectivity, access to parks, and access to shops + services; model 3 added weekend, sex, race, age, health, income, Detroit, and Phoenix; and model 4 added cross-level interaction terms to test the main hypotheses. Model 4 can be found as follows:

$$\text{PhysicalActivity}_{ti} = \pi_{0i} + \pi_{1i} \times \text{HotDay}_{ti} + \pi_{2i} \times \text{RainyDay}_{ti} + \pi_{3i} \times \text{WeekendDay}_{ti} + e_{ti},$$

$$\pi_{0i} = \beta_{00} + \beta_{01} \times \text{Sex}_i + \beta_{02} \times \text{Race}_i + \beta_{03} \times \text{Age}_i + \beta_{04} \times \text{Health}_i + \beta_{05} \times \text{Income}_i + \beta_{06} \times \text{Detroit}_i + \beta_{07} \times \text{Phoenix}_i + \beta_{08} \times \text{Density}_i + \beta_{09} \times \text{Safety}_i + \beta_{010} \times \text{Trees}_i + \beta_{011} \times \text{Hillilness}_i + \beta_{012} \times \text{Connectivity}_i + \beta_{013} \times \text{AcessParks}_i + \beta_{014} \times \text{AccessShopsServices}_i + r_{01},$$

$$\pi_{1i} = \beta_{10} + \beta_{11} \times \text{Density}_i + \beta_{12} \times \text{Safety}_i + \beta_{13} \times \text{Trees}_i + \beta_{14} \times \text{Hilliness}_i + \beta_{15} \times \text{Connectivity}_i + \beta_{16} \times \text{AccessParks}_i + \beta_{17} \times \text{AccessShopsServices}_i,$$

$$\pi_{2i} = \beta_{20_i},$$

$$\pi_{3i} = \beta_{30_i},$$

where π_{0i} = level 1 intercept; π_{1i}, π_{2i}, ... = slope coefficients of level 1 variables; e_{ti} = level 1 error term; β_{00} = level 2 intercept; β_{01}, β_{02}, ... = slope coefficients of level 2 variables; and r_{01} = level 2 error term.

Results

Study individuals ($n_{individuals} = 134$) averaged spending about 1 hour per day engaged in any activity, and a half-hour per day engaged in recommended activity (Table 1). The average daily maximum heat index varied by city: 98.6°F in Atlanta (minimum = 91.0°F, 25th percentile = 96.6°F, 75th percentile = 100.6°F, maximum = 104.4°F); 87.6°F in Detroit (minimum = 71.9°F, 25th percentile = 82.4°F, 75th percentile = 92.8°F, maximum = 102.1°F); and 104.0°F in Phoenix (minimum = 91.0°F, 25th percentile, 75th percentile = 109.2°F, maximum = 109.3°F). Hot days constituted 43.4% of the study days. The average daily maximum heat index was found to be higher on hot days (100.1°F [3.7°F]) than all other study days (92.4°F [9.6°F]), a statistically significant difference (95% confidence interval, –8.6 to –6.6). Regarding characteristics of the built environment, the average mean block size—a proxy for residential density—within 800 m of home was 18.8 acres. The majority of individuals (ie, 90%) felt safe in their neighborhood. Individuals had an average of 22.6% tree canopy and 2.3° slope within 800 m of home. Regarding access to behavior settings, individuals had an average of 230.1 road intersections (ie, a proxy for connectivity), 24.0 acres of parkland, and 136.2 shops + services within 800 m of home. There were no significant differences in mean outdoor physical activity on hot days versus cooler days for both any activity and recommended activity (Figure 2).

Within the 4 model sets, this analysis reported on model 3 because these models had the best fit, as determined by Akaike information criterion and Bayesian information criterion (Tables 2 and 3). For both any activity and recommended activity, model 3 showed no significant associations with both hot days and any of the built environment features, holding all other variables constant ($P > .10$). For any activity, being non-White was associated with a 47% decrease in daily minutes of physical activity ($P < .10$). For recommended activity, living in Detroit was associated with a 46% decrease in daily minutes of physical activity ($P < .10$). For both any activity and recommended activity, all other model variables exhibited insignificant associations with daily minutes of outdoor physical activity ($P > .10$). In the final, most elaborate model (model 4), none of the cross-level interactions were significant ($P > .10$) for either any activity or recommended activity.

Discussion

This study found hot days and not hot days to have similar patterns of impact on the 7 built environment features and outdoor physical activity of adults. As such, we cannot reject the null hypothesis of no difference in the magnitude of the expected directional effect of all built environment features on outdoor physical activity levels. The insignificant association between hot days and outdoor physical activity corroborates the results of another study that also used physical activity diaries, which found statistically or substantively insignificant correlations between temperature and transport-related physical activity to shopping, food, and school destinations.[41] Regarding built environment features, a systematic review and meta-analyses found that physical activity of older adults exhibited insignificant associations with density ($P = .39$), connectivity ($P = .09$), and hills ($P = .21$), and significant positive associations with safety, greenery, access to parks, and access to shops + services ($P < .01$)[42]; however, not all studies included in the systematic review and meta-analyses exhibited significant positive associations with safety, greenery, access to parks, and access to shops + services.[43–46]

Several possible reasons exist for why study results did not support study hypotheses. During hot weather, individuals may not be actively seeking those built environment features that exhibit positive associations with physical activity in the literature (ie, safety, trees, connectivity, access to parks, and access to shops + services) or avoiding those built environment features that exhibit negative associations with physical activity in the literature (ie, density as mean block size and hilliness), because they (1) have high behavioral thresholds to heat due to acclimatization, (2) do not perceive heat as a health threat, (3) lack access to any or accurate weather information, (4) adjusted behavior to heat, and (5) have inflexible schedules.[47–51]

The research design and methodology have limitations. First, the relatively small sample of 134 individuals reduces the statistical power and increases the chance of type II errors. Second, this work is subject to omitted variable bias, which prevents the determination of a causal relationship between predictors and physical activity. Third, the use of self-report to develop the dependent variables of outdoor physical activity decreases reliability and validity due to accidental input errors, response bias, and recall bias.[52] While self-reported measures have been shown to elevate physical activity levels above direct measures (eg, accelerometry),[53] study participants may have further inflated their physical activity levels because of thermal discomfort when physically active in hot conditions. Fourth, we did not stratify the study sample by level of historical physical activity; individuals who habitually engage in physical activity may not change their physical activity levels due to high temperatures, presence of built environment features that are barriers to physical activity, and lack of built environment features that are facilitators of physical activity.

As a fifth limitation, defining hot days from a daily measurement does not capture whether individuals shifted their physical activity to cooler portions of the day, and the use of maximum heat index assumes study participants modified activity behavior based

Table 1 Pooled 3-City Descriptive Statistics

Variable	Count	% of total	Mean	SD
Level 1 time-varying variables				
Physical activity				
Any activity, outdoor, (daily minutes)			60.7	96.3
Recommended activity, outdoor, (daily minutes)			29.8	74.0
Weather				
Daily maximum heat index, Atlanta, °F			98.6	2.7
Daily maximum heat index, Detroit, °F			87.6	7.5
Daily maximum heat index, Phoenix, °F			104.0	5.1
Hot day	322	43.4		
Rainy day	204	27.5		
Time				
Weekend day	178	24.0		
Level 2 time-invariant variables				
Individual				
Sex (female)	87	64.9		
Race (nonwhite)	70	52.2		
Age, y			44.9	16.6
Health (not good health)	35	26.1		
Income, $			65,130	59,388
Environment				
Density (mean block size, acres)[a]			18.8	40.7
Safety (neighborhood unsafe)	10	7.5		
Trees (%canopy)[a]			22.6	20.3
Hilliness (mean slope, deg)[a]			2.3	2.3
Connectivity (no. of road intersections)[a]			230.1	82.7
Access to parks,[a] acres			24.0	39.0
Access to shops + services (no. of commercial)[a]			136.2	94.6

[a]Within 800 m of each study participant's home address.

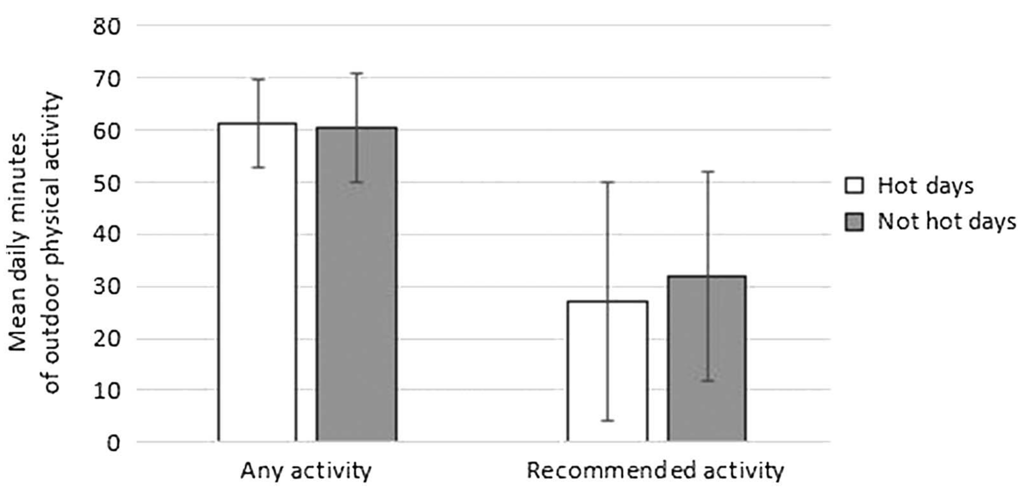

Figure 2 — Mean daily minutes of outdoor physical activity, stratified by physical activity intensity and temperature. Error bars indicate the 95% confidence interval.

on forecasted maximum temperatures, not mean or minimum values. Sixth, data for all built environment variables were collected at different times than the physical activity data, which may have resulted in built environment data that did not match what study participants experienced when completing time activity diaries. Finally, restricting built environment features to within an 800 m distance of participants' home addresses assumes outdoor physical activity of study participants took place near the home.

Table 2 Estimates of Fixed Effects for Growth Curve Models: How Hot Days Moderate the Relationship Between Built Environment Features and Outdoor Physical Activity (Any Activity)

	Any activity[a]			
	Model 1	Model 2	Model 3	Model 4
Fixed effects				
Intercept	2.59*	2.37*	3.83*	3.47**
Level 1 time-varying variables				
Weather				
Hot day (0 = not hot day)		–0.05	0.01	0.04
Rainy day (0 = not rainy day)		–0.15	–0.20	–0.19
Weekend day (0 = not weekend)			–0.06	–0.03
Level 2 time-invariant variables				
Individual				
Sex (0 = male)			–0.53	–0.52
Race (0 = white)			–0.67**	–0.67**
Age (0 = 44.9 y)[b]			–0.01	–0.01
Health (0 = good health)			–0.47	–0.47
Income, $			–0.02	–0.02
City of residence[c]				
Detroit (0 = not Detroit)			–0.54	–0.51
Phoenix (0 = not Phoenix)			–0.49	–0.41
Environment				
Density (mean block size, acres)[d]		–0.01**	–0.01	–0.01
Safety (0 = neighborhood safe)		–0.06	–0.27	–0.57
Trees (%canopy)[d]		0.01	0.01	0.01
Hilliness (mean slope, deg)[d]		0.13	–0.07	–0.07
Connectivity (no of road intersections)[d]		0.01	–0.01	0.01
Access to parks (acres)[d]		–0.01	–0.01	0.01
Access to shops + services (no. of commercial)[d]		–0.01	–0.01	–0.01
Cross-level interactions				
Hot day × density[b,d]		–0.01**	–0.01	–0.01
Hot day × safety[b]		–0.06	–0.27	0.59
Hot day × trees[b,d]		0.01	0.01	–0.01
Hot day × hilliness[b,d]		0.13	–0.07	–0.02
Hot day × connectivity[b,d]		0.01	–0.01	–0.01
Hot day × access to parks[b,d]		–0.01	–0.01	–0.01
Hot day × access to shops + services[b,d]		–0.01	–0.01	–0.01
τ_{00} (intercept)	2.00*	1.96*	1.91*	1.91*
σ^2	–0.01	–0.02	–0.04	–0.03
Model fit				
AIC	3050.0	2927.9	2418.0	2461.2
BIC	3063.8	2941.5	2431.1	2474.2

Abbreviations: AIC, Akaike information criterion; BIC, Bayesian information criterion.
[a]Log transformed. [b]Mean centered. [c]Reference city = Atlanta. [d]Within 800 m of each study participant's home address.
*$P < .05$. **$P < .10$.

In reality, individuals may choose to be physically active outside of this near-home environment.

If future work can confirm our findings that hot weather does not impact physical activity, then individuals who engage in physical activity in hot conditions may be placing themselves at increased risk for exertional heat illness (EHI). When performing physical activity in hot and humid environments, thermoregulation is a physiological challenge due to the multiple stressors put on the body and its cardiovascular system.[54] If individuals are unable to shed body heat in a timely manner, then heat illness—on a continuum from heat exhaustion to the medical emergency of heat stroke—can occur.

This work recommends that cities allocate resources for reducing EHI risk, and do so by incorporating EHI risk within HIAs and designing urban heat management strategies through the lens of physical activity. For plans, projects, and policies that have the

Table 3 Estimates of Fixed Effects for Growth Curve Models: How Hot Days Moderate the Relationship Between Built Environment Features and Outdoor Physical Activity (Recommended Activity)

	Recommended activity[a]			
	Model 1	**Model 2**	**Model 3**	**Model 4**
Fixed effects				
Intercept	1.47*	2.02*	4.68*	5.24*
Level 1 time-varying variables				
Weather				
Hot day (0 = not hot day)		0.03	0.10	0.18
Rainy day (0 = not rainy day)		–0.20	–0.24	–0.25
Weekend day (0 = not weekend)			–0.03	–0.06
Level 2 time-invariant variables				
Individual				
Sex (0 = male)			–0.37	–0.36
Race (0 = white)			–0.06	–0.07
Age (0 = 44.9 y)[b]			–0.01	–0.01
Health (0 = good health)			–0.40	–0.38
Income, $			–0.05	–0.02
City of residence[c]				
Detroit (0 = not Detroit)			–1.70**	–1.89**
Phoenix (0 = not Phoenix)			–0.91	–1.16
Environment				
Density (mean block size, acres)[d]		–0.01	–0.01	–0.01
Safety (0 = neighborhood safe)		0.12	–0.31	–0.72
Trees (%canopy)[d]		–0.01	–0.01	–0.02
Hilliness (mean slope, deg)[d]		0.10	–0.25	–0.22
Connectivity (no. of road intersections)[d]		–0.01	–0.01	–0.01
Access to parks, acres[d]		–0.01	0.01	0.01
Access to shops + services (no. of commercial)[d]		–0.01	–0.01	–0.01
Cross-level interactions				
Hot day × density[b,d]				0.01
Hot day × safety[b]				0.95
Hot day × trees[b,d]				0.02
Hot day × hilliness[b,d]				–0.11
Hot day × connectivity[b,d]				0.01
Hot day × access to parks[b,d]				–0.01
Hot day × access to shops + services[b,d]				–0.01
τ_{00} (intercept)	1.31*	1.39*	1.34*	1.40*
σ^2	0.06	0.05	0.09	0.09
Model fit				
AIC	2887.8	2825.7	2332.8	2373.9
BIC	2901.5	2839.3	2345.8	2386.8

Abbreviations: AIC, Akaike information criterion; BIC, Bayesian information criterion.
[a]Log transformed. [b]Mean centered. [c]Reference city = Atlanta. [d]Within 800 m of each study participant's home address.
$*P < .05$. $**P < .10$.

potential to impact physical activity spaces, interdisciplinary HIA teams can include a climatologist to conduct a thermal audit for the area of concern. The HIA can reveal when a plan, project, or policy decreases mean radiant temperature (T_{mrt}; ie, the sum of all shortwave and longwave radiation to which one is exposed)[55] and, therefore, may safeguard individuals from heat-related illness. Conversely, HIAs can alert of increases in T_{mrt}, which may call for heat management strategies to moderate the possible health threat.

If an HIA reveals an increase in T_{mrt}, city planners can then employ heat management strategies to defend against EHIs. Planners commonly utilize greening strategies (ie, vegetative enhancements) and the installation of cool materials (ie, reflective building materials) to reduce urban heat islands. Cities can implement greening strategies at those locations where individuals are partaking in physical activity such as on and around physical activity infrastructure (eg, sidewalks and bike lanes) and install cool materials on urban surfaces that are not primarily utilized for physical activity (eg, roads and parking lots). Tree planting is a particularly effective heat management strategy: climate models found that every 1% increase in tree canopy decreased air temperatures by 0.14°C in a Phoenix neighborhood.[56] Regarding cool materials, the installation of a cool coating on road surfaces in Los Angeles, CA, lowered summer temperatures by as much as 10°F.[57]

Conclusions

This study provides further evidence of how environmental factors impact outdoor physical activity levels of adults. Hot days did not increase the magnitude of the expected directional effect of built environment features on outdoor physical activity levels. Results may indicate that in high temperature conditions, individuals do not reach levels of thermal discomfort that would induce increased sensitivity to built environment features on their activity behavior. Since the impact of built environment features on outdoor physical activity was not magnified by heat, individuals engaging in physical activity on hot days may not be seeking heat-protective built environment features, such as trees, and may not be avoiding heat-generating built environment features, such as urban density. To potentially protect the health of active adults in hot weather, this work recommends incorporating the risk of EHI within HIAs and designing urban heat management strategies with outdoor physical activity in mind.

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