



The social context moderates the relationship between neighborhood safety and adolescents' activities

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ARTICLE INFO

Article history:

Received 20 February 2017

Received in revised form 19 April 2017

Accepted 23 April 2017

Available online 26 April 2017

ABSTRACT

Studies of neighborhood safety and physical activity have typically neglected to consider the youth's peer context as a modifier of these relationships. This study fills this gap in testing the independent and interactive effects of perceived neighborhood safety and time spent with friends and peers on young adolescents' physical activity and sedentary behavior. Participants (N = 80; ages 13–17) completed the Pedestrian/Traffic Safety and Crime Safety subscales of the adolescent version of the Neighborhood Environment Walkability Scale (NEWS). An experience sampling methodology was used to assess sedentary behaviors/screen time and the social context in which physical activity and sedentary time/behavior occurred. Physical activity was assessed via accelerometry. Multilevel models were used to estimate the relationships between predictors (neighborhood safety and social context) and outcomes (physical activity and sedentary time/behavior). Frequency of peer/friend interactions moderated the relationships between neighborhood safety and adolescents' physical activity and sedentary behavior. Specifically, physical activity was more strongly influenced by neighborhood safety among adolescents who reported spending less time with peers and friends than among those who reported frequent peer interactions. Among youths who perceived that their neighborhoods were safer, spending more time with friends and peers was related to greater engagement in sedentary activities, whereas this was not the case among adolescents who perceived that their neighborhoods were less safe. The peer social context moderates the relationship between perceived neighborhood safety and adolescents' physical activity and sedentary behavior. Improving social interactions at the individual level within neighborhoods may decrease concerns of safety.

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1. Introduction

Regular physical activity and active play during adolescence is associated with several short- and long-term physical and psychological benefits (e.g., Janz et al., 2006). Unfortunately, many youths do not participate in recommended amounts of activity (Crespo et al., 2001) and research is needed to understand factors associated with adolescents' choices of activities. A number of studies have focused on the associations between neighborhood characteristics, including parent perceived safety, and youths' physical activity (Burdette and Whitaker, 2004, 2005; D'Haese et al., 2014; Galvez et al., 2013; Holt et al., 2009; Maddock, 2004; H. J. Moore et al., 2014; Morland and Evenson, 2009; Simmons et al., 2005; Weimann et al., 2015). Findings from this literature are mixed, with some studies showing relationships between neighborhood characteristics and youths' engagement in physically active leisure activities, and others finding no or equivocal associations

(e.g., Saelens and Handy, 2008). One explanation for the lack of consensus among studies may be that previous research has focused on the impact of parent perceived neighborhood safety on their children's physical activity and sedentary behavior, and less is known about the role of youths' perceptions of safety in relation to their own behavior (Cote-Lussier et al., 2015a; Cote-Lussier et al., 2015b). Youths' perceptions of safety may be especially important as children get older and gain increasing autonomy. Previous models of perceived neighborhood safety have also typically neglected to consider youths' peer and friend interactions as key modifiers of the relationships between perceived safety and physically active and sedentary activities. Adolescents spend the majority of their waking hours in the company of peers and friends. Consequently, limited social opportunities and aloneness can be decisive in narrowing adolescents' choices of activities (e.g., Salvy et al., 2012a). Our work clearly indicates that children and adolescents' choices of activities are strongly influenced by the presence of peers and friends. Specifically, in a series of studies we showed that spending time alone (Salvy et al., 2009; Salvy et al., 2008) and social exclusion (ostracism) decrease physical activity (Barkley et al., 2012). Conversely, co-engaging in activities with peers and friends increase youths'

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motivation to be physically active and objectively measured physical activity (Barkley et al., 2014; Dunton et al., 2007; Rittenhouse et al., 2011; Salvy et al., 2008; Salvy et al., 2009; Sanders et al., 2014).

Without minimizing the impact of neighborhood safety on adolescents' choices of activity, we hypothesize that the neighborhood environment and social factors work jointly to account for adolescents' physical activity and health. The availability of peers and friends to engage in outdoor activities likely influence youths' perception of safety whereas engaging in these activities alone may confer a greater feeling of vulnerability. This is important, as social relationships are arguably more amenable to change than neighborhood infrastructures. Improving social interactions at the individual level within neighborhoods may decrease youths' feelings of vulnerability and fear for safety through collective efficacy and social cohesion (Ball et al., 2010; Foster and Giles-Corti, 2008). Conversely, policies and interventions focused on the neighborhood environment alone may not be as effective in absence of strategies simultaneously leveraging youths' social and community relationships.

This study tests the independent and interactive effects of adolescents perceived neighborhood safety and social interactions (time alone or with peers and friends) on youth physical activity and sedentary/screen time behavior. We hypothesize that youths' social interactions with peers and friends moderate (attenuate) the relationships between perceived neighborhood safety and engagement in physically active or sedentary activities. We focused on physical activity and sedentary behavior as both are considered important and independent determinants of adolescents' health (Ekelund et al., 2007; Knaeps et al., 2016; Martinez-Gomez et al., 2010; Santos et al., 2014). There is also evidence that decreasing adolescents' screen time does not automatically result in increased physical activity (Epstein et al., 2008), suggesting that physical activity and sedentary behavior may not be interdependent and influenced by different mechanisms (O'Connor et al., 2013).

2. Method

2.1. Participants and procedure

Forty pairs of same-sex biologic siblings (ages 13–17, no >4 years apart) were originally recruited as part of a larger study evaluating putative factors contributing to differences in energy balance behaviors and adiposity among weight-discordant siblings (Fedra et al., 2015). The weight-discordant sibling design increases the innovation of this study and makes it possible to control for approximately 50% of the genetic variability between siblings, and for some degree of the variance associated with shared aspects of the home and neighborhood environments.

Families were recruited from newspaper advertisements and from a database of families who had inquired about previous studies. Parents were screened by phone for their children's height, weight, a brief medical history, and ethnic background. Children were excluded if they were below the 10th BMI percentile; had current psychopathology or developmental disability; and/or if they were on medications or had conditions that could influence their mobility or their activity level (e.g., methylphenidate). If a sibling had a cold or upper respiratory distress they were rescheduled for testing. A total of 930 families contacted the study staff regarding the study. From the original pool, 234 families did not return our call or were unable to complete the initial phone screen. A large number ($n = 652$) of contacted families were not eligible for the study (e.g., different parents, siblings were twins). The remaining 44 families were enrolled in the study and four families dropped out before completion. All study procedures were approved by the Social and Behavioral Sciences Institutional Review Board of the University at Buffalo. Parents provided written informed consent for each sibling and the siblings provided assent.

2.2. Measures

2.2.1. Covariates

2.2.1.1. Baseline participant characteristics. Siblings were asked to report their demographic information including gender, age, grade-level, school and race/ethnicity. Parents provided parents' education and household income.

2.2.1.2. BMI z-score (zBMI). Participants' height and weight were assessed using an electronic scale (Model BWB-800S, Tanita, Portage, MI) and digital stadiometer (Model PE-AIM-101, Perspective Enterprises). Body weight was measured to the nearest 0.01 kg and height to the nearest 0.1 cm. Participants were asked to remove their shoes, belts, and heavy outerwear and to empty their pockets. Height was measured in duplicate and if measurements were not within 0.5 cm, we obtained a third measurement. The weight data and mean of all height measurements were used to calculate BMI (kg/m^2) percentiles and z-scores (Centers for Disease Control and Prevention, 2000). BMI z-scores were entered as covariate in all analyses.

2.2.2. Outcomes

2.2.2.1. Physical activity. Physical activity was measured using the MTI *Actigraph* (Pensacola, FL) activity monitor. The *Actigraph* is a small ($5.1 \times 3.8 \times 1.5$ cm), lightweight accelerometer worn around the waist that collects measures of raw acceleration, activity amount and intensity. The *Actigraph* has been validated in adolescents (Robusto and Trost, 2012; Romanzini et al., 2014; Vanhelst et al., 2011). Activity was monitored and recorded for 5 weekdays and 2 weekend days. Youth received written instructions on use, including appropriate care and placement on the right iliac crest using a provided belt and had to wear the *ActiGraph* at least 10 h/day for the day to meet the criterion for a full measurement day. The *ActiGraph* was initialized for 15-second epochs. Downloaded data were cleaned of spurious lines of >16,000 counts and negative counts. Sequences of 20+ min of consecutive zero counts were scored as non-wear time. The main outcome variable is the average counts/minute, an index of average total physical activity.

2.2.2.2. Sedentary behaviors/screen time. The frequency of sedentary behaviors/screen time activities was captured using an experience sampling methodology (ESM) or ecological momentary assessment (EMA). EMA/ESM have been used to study a range of phenomena in psychology and behavioral medicine (Chen et al., 2015; Csikszentmihalyi and Larson, 1987; Davidson et al., 2016; Ebner-Priemer et al., 2009; Engel et al., 2016; Huhn et al., 2016; Linas et al., 2016; Moore et al., 2016; Schuster et al., 2016). We have used this methodology to assess the relationship between social context and physical activity in young adolescents (Salvy et al., 2008) and validated this approach using objective accelerometry (Salvy et al., unpublished manuscript). In the validation study, metabolic equivalent (MET) values estimated from participants' report of their activities based on the children's compendium of physical activity were compared to MET values estimated from accelerometer activity counts. Both methodologies (ESM and accelerometry) yielded similar conclusions with regard to the influence of social context on youth's physical activity. In the present study, each participant was given a cell phone to receive and send text messages related to the study. Text messages were sent to participants for 5 weekdays and 2 weekends, approximately every 2 h between 15:00 and 21:00 on weekdays, and between 10:00 and 22:00 on weekend days. The text message alerted participants to indicate the activity they were doing (e.g., screen time, eating, physical activity); the perceived difficulty of the activity (e.g., sitting, walking, running) and the duration of activity (<5 min, 6–10 min, 11–15 min, 16–20 min, 21+ min). We focused on the time engaged in screen-based activities (e.g., sending/receiving email or

text messages; watching television; or playing video games), rather than school-related activities to capture leisure-time screen usage. Research staff kept a record of participants responding. If there was an issue with the participant's responses (e.g., missing or unclear response), the staff contacted them the next working day to clarify. In general, participants were very responsive and rarely lagged behind in sending their responses.

2.2.3. Predictors

2.2.3.1. Perceived neighborhood (un)safety. Participants completed the *Pedestrian/Traffic Safety* and *Crime Safety* subscales of the Neighborhood Environment Walkability Scale (NEWS) Adolescent version (Rosenberg et al., 2009). The seven *Pedestrian/Traffic Safety* items assessed traffic speed, street lighting and crosswalks in regard to impeding safety in the neighborhood (e.g., *Most drivers go faster than the posted speed limits in my neighborhood*). The six *Crime Safety* items assessed perceived crime rate and dangerousness in the neighborhood (e.g., *I am worried about being in a local/nearby park because I am afraid of being taken or hurt by a stranger*). The 4-point response format ranges from “strongly disagree” to “strongly agree.” The higher the score, the more participants perceived their neighborhood as “unsafe.”

2.2.3.2. Social context. The activity-related social context was captured using the EMA/ESM methodology described above. Participants were asked to report the social context (alone or with friends and peers) in which sedentary activities and physical activity occurred.

2.2.4. Analytic models

This analysis focuses on the relationships between perceived neighborhood safety and physical activity and how the presence of friends and peers (instances with friends/peers) influences this relationship. Our sample involved siblings, who are clustered within families. Consequently, multilevel models were used to estimate parameters in the presence of clustering, with random intercepts at the family level (Pituch et al., 2006; Preacher et al., 2010; Wang et al., 2011), using PROC MIXED models in the SAS software, Version 9.4 (SAS, 2013). Mixed models incorporate both random and fixed effects into the model, it assumes that the random effect (family) accounts for the correlation between measures from the same cluster. For each health behavior outcome, a main effects model was estimated (Model 1), followed by models with interaction terms: Model 2a: neighborhood safety x instances being alone; Model 2b: neighborhood safety x instances being with friends (Feng et al., 2009). The tests of the hypotheses related to main effects of predictors on outcomes were evaluated in models that did not include interaction terms. Statistically significant interaction terms were interpreted using a graphical approach. To draw the graphs, we used the “pick a point” approach (Rogosa, 1980), which involves selecting representative values (mean \pm 1 SD) of the moderator and estimating the effect of the focal predictor at those values.

3. Results

3.1. Participant characteristics

The total analytic sample included 40 pairs of same-sex biologic siblings (Table 1).

3.2. Multilevel regression model results

All models controlled for siblings' zBMI, age, gender, household socioeconomic status (SES), which includes both parents' income and education. The coefficients for these covariates are not shown in Table 2 as these variables were not significant predictors of physical activity or sedentary behavior.

Table 1
Participant characteristics (n = 80).

Outcomes		Mean (SD; range or N%)
Outcomes	Sedentary time (instances/week)	23.3 (11.0; 6–61)
	Accelerometer counts (counts/minute)	344 (125; 161–790)
Predictors	Perceived neighborhood safety	21.8 (3.8; 13–31)
	Instances with friends and peers	8.9 (5.8; 0–25)
	Instances alone	10.5 (6.2; 0–27)
	zBMI (kg/m ²)	0.78 (0.89; –1.45–2.42)
	Household income*	5.4 (2.8; 1–10)
	Mother's education**	6.4 (1.4; 4–8)
	Father's education**	5.9 (1.4; 3–8)
Age (years)		15.4 (1.4; 13.0–17.8)
Male (n)		46 (57.5%)
Race/Ethnicity	Black (n)	4 (5%)
	Hispanic (n)	2 (2.5%)
	Multiracial/Other (n)	2 (2.5%)
	White (n)	74 (92.5%)

Note: *household income: 1 to 10 scale, where 1 = under \$9999, 10 = over 200,000; **parents education: 1 to 8 scale, where 1 = less than 7th grade, 8 = completed graduate degree. The majority of parents (>50%) had completed a 4-year degree and had an annual income between \$70,000 and \$89,999.

3.2.1. Physical activity

The number of instances youths spent alone was negatively correlated with average accelerometer counts ($p = 0.03$; Table 2). Importantly, time spent with peers and friends moderated the relationship between perceived neighborhood safety and physical activity in Model 2. Specifically, the (negative) relationship between neighborhood safety and physical activity was stronger among adolescents who reported spending less time with peers and friends than for those who reported frequent peer interactions ($p = 0.04$; Table 2; Fig. 1).

3.2.2. Hours of sedentary activities

Perceived lack of neighborhood safety (higher score = more unsafe) was negatively correlated to sedentary time in Model 1 ($p = 0.01$; Table 2). This relationship was subsequently qualified by time spent with friends and peers in Model 2 ($p = 0.0014$; Table 2; Fig. 2). Specifically, among youths who perceived that their neighborhoods were safer, spending more time with friends and peers was correlated with greater engagement in sedentary activities, whereas this was not the case among adolescents who perceived that their neighborhoods were less safe.

4. Discussion

To our knowledge, this is the first study to simultaneously consider adolescent perceived neighborhood safety and social interactions as

Table 2
Results of mixed effect models (multilevel regression estimates) for sedentary time and physical activity.

Predictors	Physical activity	Sedentary time
Model 1 estimates (95% CIs)		
Instances alone	–6.72 (–12.72, –0.71)*	–0.01 (–0.49, 0.46)
Instances with friends/peers	19.37 (–5.56, 44.31)	0.98 (–0.95, 2.92)
Neighborhood safety	–3.88 (–12.50, 4.73)	–0.85 (–1.52, –0.18)*
Model 2 estimates (95% CIs)		
Instances alone	–7.38 (–13.25, –1.51)*	–0.52 (–0.43, 0.34)
Instances with friends/peers	–11.50 (–51.00, 27.69)	3.89 (1.33, 6.45)**
Neighborhood safety	–21.10 (–39.36, –2.79)*	1.04 (–0.06, 2.15)
Neighborhood safety x friends/peers	1.63 (0.07, 3.19)*	–0.17 (–0.27, –0.07)**

Note: all models control for zBMI, age, gender, and SES which included parents' income and education (n.s., not shown). * $p < 0.05$; ** $p < 0.01$. For each outcome, a main effects model was estimated (Model 1), followed by Model 2 testing the interaction of neighborhood safety by instances with friends and peers.

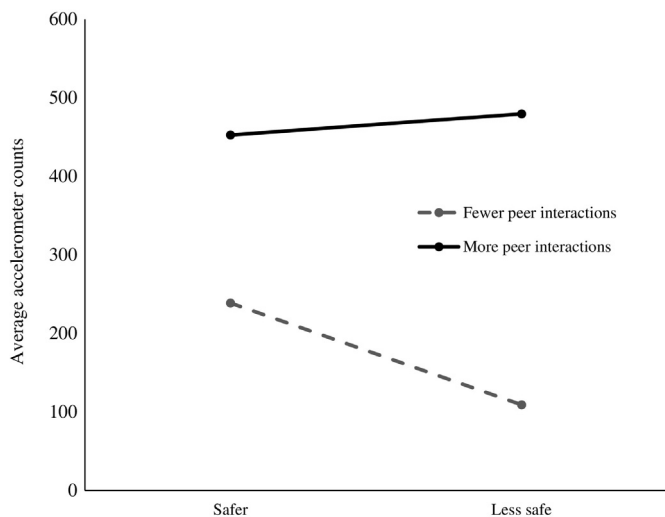


Fig. 1. Time spent with friends and peers moderates the relationship between perceived neighborhood safety and sedentary/screen time activities.

independent and interactive predictors of adolescents' physical activity and sedentary behavior. This study further included ESM/EMA assessment of social context and objective accelerometry to measure physical activity.

The youth social context qualifies the relationships between adolescent perceived neighborhood safety and physical activity and sedentary behavior. Importantly, neighborhood safety was predictive of physical activity only among youths who spent less time with peers and friends. For adolescents who had frequent social interactions, perceived neighborhood safety was not a significant predictor of physical activity. These findings are consistent with previous work on the beneficial influence of peers and friends on physical activity (Barkley et al., 2014; de la Haye et al., 2011; Faith et al., 2002; Gubbels et al., 2011; Larson et al., 2013; Rittenhouse et al., 2011; Salvy et al., 2012a; Salvy et al., 2008; Salvy et al., 2012b; St George and Wilson, 2012; Stock et al., 2007; Storch et al., 2007; Voorhees et al., 2005). The present study extends previous studies in indicating that positive relationships with peers and friends may buffer the potential adverse effects of neighborhood environment on physical activity. These findings are akin to those of Franzini and her colleagues who found that a favorable social environment was positively associated with physical activity, irrespective of neighborhood sociodemographic factors (Franzini et al., 2009).

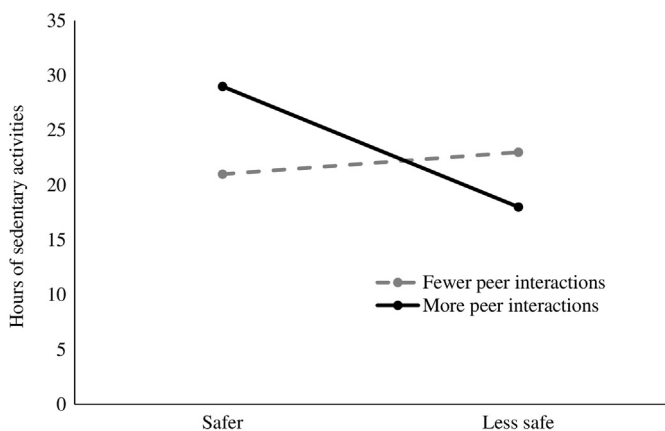


Fig. 2. Time spent with friends and peers moderates the relationship between perceived neighborhood safety and sedentary/screen time activities. Among youths who perceived that their neighborhoods were safer, spending more time with friends and peers was related to greater engagement in sedentary activities, whereas this was not the case among adolescents who perceived that their neighborhoods were less safe.

Conceivably, peers and friends not only provide more opportunities to engage in physically active leisure activities, but also confer a greater sense of safety, possibly through collective efficacy and social cohesion (Ball et al., 2010; Foster and Giles-Corti, 2008).

Time spent with peers and friends also moderated the relationship between neighborhood safety and adolescents' sedentary behavior. Specifically, among youths who perceived that their neighborhoods were less safe, adolescents who had fewer social interactions spent more time engaged in screen time activities than adolescents who interacted more frequently with peers and friends. By contrast, among youths who perceived that their neighborhoods were safer, those who spent more time with peers and friends participated in more sedentary activities than youths who had fewer interactions. A recent cross-sectional study of 528 Australian children indicated that, regardless of socioeconomic status, the availability of televisions, cell phones and other screen equipment and consoles is positively associated with children's screen time activities (Dumuid et al., 2016). Adolescents may congregate in the houses of their friends who have a greater availability and variety of video games or electronic equipment, which, in turn, may correlate with greater perception of neighborhood safety through other variables. However, this contention is purely hypothetical as socioeconomic status- a potential correlate of ownership of TVs and electronic devices- was not a significant predictor of perceived neighborhood safety, physical activity or sedentary behavior in the present study.

A possible ancillary explanation for these findings relates to social norms prevailing among friends. Adolescents tend to befriend peers who are similar or who share common interests and activities, a phenomenon known as homophily (Marks et al., 2015). Adolescents' choice of leisure activities may be determined to a greater extent by environmental (e.g., neighborhood safety) or situational (e.g., boredom) factors when youths have few social opportunities. However, in a social context, adolescents might emulate and/or co-engage in normative behaviors that prevail in their peer group. Unfortunately, peer norms around sedentary and physically active leisure activities were not assessed in this study, so it is unclear whether activity-related norms differ as a function of participants' perceived neighborhood safety. Though it may seem counterintuitive that greater peer interactions can be associated with both greater physical activity and greater hours of sedentary activities, there is evidence that physical activity and sedentary behavior are independent behaviors (Epstein et al., 2008), especially in youth as they have adequate free-time to be both highly active and highly sedentary (Biddle et al., 2004). Consistent with the notion of homophily, these findings may also reflect the behavior of distinct social groups who share similar interests for sedentary activities (Bender and Losel, 1997; Ennett and Bauman, 1994; Lansford et al., 2009; Lodder et al., 2016; Sawka et al., 2014).

4.1. Limitations

Despite collecting real-time data and accelerometry, we cannot make definitive conclusions regarding the directionality of the associations. For instance, the finding that youth who reported being with peers and friends more frequently were more physically active than youth who had fewer social interactions could be explained by reverse causality, whereby youth who are more physically active are more frequently with peers and friends. Longitudinal work is needed in this area to help disentangle causality in social influence.

Another limitation of this study is that we measured adolescents' perceptions of neighborhood safety rather than objectively defined neighborhood environment. Perceived and objective measures of neighborhood safety may or may not reflect similar features of the environment. Sallis and colleagues (Sallis et al., 2006) distinguish between perceptions of the environment and the objectively measured environment by placing them at different levels of influence within the ecological model of active living. In their recent review, Orstad and her

colleagues (Orstad et al., 2016) found that perceived neighborhood environment was associated with physical activity at greater rates than objective neighborhood environment (20.1% and 13.7%), indicating that the perceived and objectively measured neighborhood environment are correlated, but distinct constructs that account for unique variance in physical activity.

Finally, we did not assess the location where participants were physically active or sedentary. The settings in which activities take place are highly relevant when analyzing the effects of perceived neighborhood safety, especially at the light of emergent place-based interventions addressing contextual factors that contribute to health disparities (Smedley and Amaro, 2016). Similarly, this study did not include measures of neighborhood social cohesion, community data on crime or activity preference that might paint a more complete picture. Future work should take advantage of advancements in neighborhood mapping and measures of social capital and cohesion to have a clearer understanding of how social determinants and objective neighborhood attributes synergistically operate on health behavior.

4.2. Conclusions

Peer influence is increasingly the focus of prevention and intervention efforts targeting health promotion in adolescence (Zhang et al., 2015). Our findings emphasize the importance of considering social factors, when examining the contribution of the neighborhood or physical environment. The ensuing step will be to test interventions that alter social context to evaluate their impact on physical activity and sedentary activities. Strategies that encourage social support, social connectedness, and collective efficacy within one's neighborhood could potentially be used to minimize the impact of neighborhood safety on health indicators. Improving social support and social interactions at the individual and community level has the potential to decrease feelings of vulnerability and fear for safety (Ball et al., 2010; Foster and Giles-Corti, 2008). Practical strategies such as community events organized around health-promoting activities (physically active classes held in local parks) encourage community members to interact with one another in the neighborhood setting (Gasevic et al., 2011; Griffin et al., 2008). To the extent that such interventions are successful in influencing physical activity, this work would provide convincing evidence that social processes are acting on health risks in a causal fashion.

Funding source

This work was funded by a grant from the Eunice Kennedy Shriver National Institute of Child Health and Human Development (R01HD064958) to James N. Roemmich and the U.S. Department of Agriculture (USDA), Agricultural Research Service, USDA 3062-51000-51-00D. The authors have no financial relationships relevant to this article to disclose.

Contributors' statements

Sarah-Jeanne Salvy: Dr. Salvy conceptualized and designed the study, carried out the initial analyses, drafted the initial manuscript, and approved the final manuscript as submitted.

Denise M. Feda: Dr. Feda coordinated and supervised the data collection, and approved the final manuscript as submitted.

Leonard H. Epstein: Dr. Epstein reviewed the manuscript, and approved the final manuscript as submitted.

James N. Roemmich: Dr. Roemmich selected the data collection instruments, critically reviewed the manuscript, and approved the final manuscript as submitted.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Conflict of interest

The contents of this publication do not necessarily reflect the views or policies of the USDA or the Agricultural Research Service, nor does mention of trade names, commercial products, or organizations imply endorsement from the U.S. government. USDA is an equal opportunity provider and employer.

Clinical trial registration

NCT02376439 (ClinicalTrials.gov identifier).

Transparency document

The Transparency document associated with this article can be found, in online version.

Acknowledgments

The authors wish to thank LuAnn Johnson, Statistician, USDA Agricultural Research Service for her assistance in reviewing Dr. Salvy's analytic plan.

References

- Ball, K., Cleland, V.J., Timperio, A.F., Salmon, J., Giles-Corti, B., Crawford, D.A., 2010. Love thy neighbour? Associations of social capital and crime with physical activity amongst women. *Soc. Sci. Med.* 71 (4), 807–814.
- Barkley, J.E., Salvy, S.J., Roemmich, J.N., 2012. The effect of simulated ostracism on physical activity behavior in children. *Pediatrics* 129 (3), e659–e666.
- Barkley, J.E., Salvy, S.J., Sanders, G.J., Dey, S., Von Carlowitz, K.P., Williamson, M.L., 2014. Peer influence and physical activity behavior in young children: an experimental study. *J. Phys. Act. Health* 11 (2), 404–409.
- Bender, D., Losel, F., 1997. Protective and risk effects of peer relations and social support on antisocial behaviour in adolescents from multi-problem milieus. *J. Adolesc.* 20 (6), 661–678.
- Biddle, S.J., Gorely, T., Marshall, S.J., Murdey, I., Cameron, N., 2004. Physical activity and sedentary behaviours in youth: issues and controversies. *J. R. Soc. Promot. Heal.* 124 (1), 29–33.
- Burdette, H.L., Whitaker, R.C., 2004. Neighborhood playgrounds, fast food restaurants, and crime: relationships to overweight in low-income preschool children. *Prev. Med.* 38 (1), 57–63.
- Burdette, H.L., Whitaker, R.C., 2005. A national study of neighborhood safety, outdoor play, television viewing, and obesity in preschool children. *Pediatrics* 116 (3), 657–662.
- Centers for Disease Control and Prevention, 2000. CDC Growth Charts: United States. Percentile Data Files With LMS Values.
- Chen, Y.W., Cordier, R., Brown, N., 2015. A preliminary study on the reliability and validity of using experience sampling method in children with autism spectrum disorders. *Dev. Neurorehabil.* 18 (6), 383–389.
- Cote-Lussier, C., Jackson, J., Kestens, Y., Henderson, M., Barnett, T.A., 2015a. A child's view: social and physical environmental features differentially predict parent and child perceived neighborhood safety. *J. Urban Health* 92 (1), 10–23.
- Cote-Lussier, C., Mathieu, M.E., Barnett, T.A., 2015b. Independent associations between child and parent perceived neighborhood safety, child screen time, physical activity and BMI: a structural equation modeling approach. *Int. J. Obes.* 39 (10), 1475–1481.
- Crespo, C.J., Smit, E., Troiano, R.P., Bartlett, S.J., Macera, C.A., Andersen, R.E., 2001. Television watching, energy intake, and obesity in US children: results from the third National Health and nutrition examination survey. *Arch. Pediatr. Adolesc. Med.* 155, 360–365.
- Csikszentmihalyi, M., Larson, R., 1987. Validity and reliability of the Experience-Sampling Method. *J. Nerv. Ment. Dis.* 175 (9), 526–536.
- Davidson, C.L., Anestis, M.D., Gutierrez, P.M., 2016. Ecological momentary assessment is a neglected methodology in Suicidology. *Arch. Suicide Res.* 1–11.
- de la Haye, K., Robins, G., Mohr, P., Wilson, C., 2011. How physical activity shapes, and is shaped by, adolescent friendships. *Soc. Sci. Med.* 73 (5), 719–728.
- D'Haese, S., Van Dyck, D., De Bourdeaudhuij, I., Deforche, B., Cardon, G., 2014. The association between objective walkability, neighborhood socio-economic status, and physical activity in Belgian children. *Int. J. Behav. Nutr. Phys. Act.* 11, 104.
- Dumuid, D., Olds, T.S., Lewis, L.K., Maher, C., 2016. Does home equipment contribute to socioeconomic gradients in Australian children's physical activity, sedentary time and screen time? *BMC Public Health* 16, 736.
- Dunton, G.F., Whalen, C.K., Jamner, L.D., Floro, J.N., 2007. Mapping the social and physical contexts of physical activity across adolescence using ecological momentary assessment. *Ann. Behav. Med.* 34, 144–153.
- Ebner-Priemer, U.W., Eid, M., Kleindienst, N., Stabenow, S., Trull, T.J., 2009. Analytic strategies for understanding affective (in)stability and other dynamic processes in psychopathology. *J. Abnorm. Psychol.* 118 (1), 195–202.

- Ekelund, U., Anderssen, S.A., Froberg, K., et al., 2007. Independent associations of physical activity and cardiorespiratory fitness with metabolic risk factors in children: the European youth heart study. *Diabetologia* 50 (9), 1832–1840.
- Engel, S.G., Crosby, R.D., Thomas, G., et al., 2016. Ecological momentary assessment in eating disorder and obesity research: a review of the recent literature. *Curr. Psychiatry Rep.* 18 (4), 37.
- Ennett, S.T., Bauman, K.E., 1994. The contribution of influence and selection to adolescent peer group homogeneity: the case of adolescent cigarette smoking. *J. Pers. Soc. Psychol.* 67 (4), 653–663.
- Epstein, L.H., Roemmich, J.N., Robinson, J.L., et al., 2008. A randomized trial of the effects of reducing television viewing and computer use on body mass index in young children. *Arch. Pediatr. Adolesc. Med.* 162 (3), 239–245.
- Faith, M.S., Leone, M.A., Ayers, T.S., Heo, M., Pietrobello, A., 2002. Weight criticism during physical activity, coping skills, and reported physical activity in children. *Pediatrics* 110 (2 Pt 1), e23.
- Feda, D.M., Roemmich, J.N., Roberts, A., Epstein, L.H., 2015. Food reinforcement and delay discounting in zBMI-discordant siblings. *Appetite* 85, 185–189.
- Feng, R., Zhou, G., Zhang, M., Zhang, H., 2009. Analysis of twin data using SAS. *Biometrics* 65, 584–589.
- Foster, S., Giles-Corti, B., 2008. The built environment, neighborhood crime and constrained physical activity: an exploration of inconsistent findings. *Prev. Med.* 47 (3), 241–251.
- Franzini, L., Elliott, M.N., Cuccaro, P., et al., 2009. Influences of physical and social neighborhood environments on children's physical activity and obesity. *Am. J. Public Health* 99 (2), 271–278.
- Galvez, M.P., McGovern, K., Knuff, C., et al., 2013. Associations between neighborhood resources and physical activity in inner-city minority children. *Acad. Pediatr.* 13 (1), 20–26.
- Gasevic, D., Vukmirovich, I., Yusuf, S., et al., 2011. A direct assessment of "obesogenic" built environments: challenges and recommendations. *J. Environ. Public Health* 2011, 161574.
- Griffin, S.F., Wilson, D.K., Wilcox, S., Buck, J., Ainsworth, B.E., 2008. Physical activity influences in a disadvantaged African American community and the communities' proposed solutions. *Health Promot. Pract.* 9 (2), 180–190.
- Gubbels, J.S., Kremers, S.P., van Kann, D.H., et al., 2011. Interaction between physical environment, social environment, and child characteristics in determining physical activity at child care. *Health Psychol.* 30 (1), 84–90.
- Holt, N.L., Cunningham, C.T., Sehn, Z.L., Spence, J.C., Newton, A.S., Ball, G.D., 2009. Neighborhood physical activity opportunities for inner-city children and youth. *Health Place* 15 (4), 1022–1028.
- Huhn, A.S., Harris, J., Cleveland, H.H., et al., 2016. Ecological momentary assessment of affect and craving in patients in treatment for prescription opioid dependence. *Brain Res. Bull.* 123, 94–101.
- Janz, K.F., Gilmore, J.M., Burns, T.L., et al., 2006. Physical activity augments bone mineral accrual in young children: the Iowa Bone Development Study. *J. Pediatr.* 148 (6), 793–799.
- Knaeps, S., Lefevre, J., Wijtzes, A., Charlier, R., Mertens, E., Bourgeois, J.G., 2016. Independent associations between sedentary time, moderate-to-vigorous physical activity, cardiorespiratory fitness and cardio-metabolic health: a cross-sectional study. *PLoS One* 11 (7), e0160166.
- Lansford, J.E., Costanzo, P.R., Grimes, C., Putallaz, M., Miller, S., Malone, P.S., 2009. Social network centrality and leadership status: links with problem behaviors and tests of gender differences. *Merrill Palmer Q. (Wayne State Univ Press)* 55 (1), 1–25.
- Larson, N.I., Wall, M.M., Story, M.T., Neumark-Sztainer, D.R., 2013. Home/family, peer, school, and neighborhood correlates of obesity in adolescents. *Obesity (Silver Spring)* 21 (9), 1858–1869.
- Linas, B.S., Genz, A., Westergaard, R.P., et al., 2016. Ecological momentary assessment of illicit drug use compared to biological and self-reported methods. *JMIR Mhealth Uhealth* 4 (1), e27.
- Lodder, G.M., Scholte, R.H., Cillessen, A.H., Giletta, M., 2016. Bully victimization: selection and influence within adolescent friendship networks and cliques. *J. Youth Adolesc.* 45 (1), 132–144.
- Maddock, J., 2004. The relationship between obesity and the prevalence of fast food restaurants: state-level analysis. *Am. J. Health Promot.* 19 (2), 137–143.
- Marks, J., de la Haye, K., Barnett, L.M., Allender, S., 2015. Friendship network characteristics are associated with physical activity and sedentary behavior in early adolescence. *PLoS One* 10, e0145344.
- Martinez-Gomez, D., Eisenmann, J.C., Gomez-Martinez, S., Veses, A., Marcos, A., Veiga, O.L., 2010. Sedentary behavior, adiposity and cardiovascular risk factors in adolescents. The AFNOS study. *Rev. Esp. Cardiol.* 63 (3), 277–285.
- Moore, H.J., Nixon, C.A., Lake, A.A., et al., 2014. The environment can explain differences in adolescents' daily physical activity levels living in a deprived urban area: cross-sectional study using accelerometry, GPS, and focus groups. *J. Phys. Act. Health* 11 (8), 1517–1524.
- Moore, R.C., Depp, C.A., Wetherell, J.L., Lenze, E.J., 2016. Ecological momentary assessment versus standard assessment instruments for measuring mindfulness, depressed mood, and anxiety among older adults. *J. Psychiatr. Res.* 75, 116–123.
- Morland, K.B., Evenson, K.R., 2009. Obesity prevalence and the local food environment. *Health Place* 15 (2), 491–495.
- O'Connor, T.M., Chen, T.A., Baranowski, J., Thompson, D., Baranowski, T., 2013. Physical activity and screen-media-related parenting practices have different associations with children's objectively measured physical activity. *Child Obes.* 9 (5), 446–453.
- Orstad, S.L., McDonough, M.H., Stapleton, S., Altincekic, C., Troped, P.J., 2016. A systematic review of agreement between perceived and objective neighborhood environment measures and associations with physical activity outcomes. *Environ. Behav.* 0013916516670982
- Pituch, K.A., Stapleton, L.M., Kang, J.Y., 2006. A comparison of single sample and bootstrap methods to assess mediation in cluster randomized trials. *Multivar. Behav. Res.* 41, 367–400.
- Preacher, K.J., Zyphur, M.J., Zhang, Z., 2010. A general multilevel SEM framework for assessing multilevel mediation. *Psychol. Methods* 15, 209–233.
- Rittenhouse, M., Salvy, S.J., Barkley, J.E., 2011. The effect of peer influence on the amount of physical activity performed in 8- to 12-year-old boys. *Pediatr. Exerc. Sci.* 23 (1), 49–60.
- Robusto, K.M., Trost, S.G., 2012. Comparison of three generations of ActiGraph activity monitors in children and adolescents. *J. Sports Sci.* 30 (13), 1429–1435.
- Rogosa, D., 1980. Comparing nonparallel regression lines. *Psychol. Bull.* 88, 307–321.
- Romanzini, M., Petroski, E.L., Ohara, D., Dourado, A.C., Reichert, F.F., 2014. Calibration of ActiGraph GT3X, Actical and RT3 accelerometers in adolescents. *Eur. J. Sport Sci.* 14 (1), 91–99.
- Rosenberg, D., Ding, D., Sallis, J.F., et al., 2009. Neighborhood Environment Walkability Scale for Youth (NEWS-Y): reliability and relationship with physical activity. *Prev. Med.* 49 (2–3), 213–218.
- Saelens, B.E., Handy, S.L., 2008. Built environment correlates of walking: a review. *Med. Sci. Sports Exerc.* 40 (7 Suppl), S550–S566.
- Sallis, J.F., Cervero, R.B., Ascher, W., Henderson, K.A., Kraft, M.K., Kerr, J., 2006. An ecological approach to creating active living communities. *Annu. Rev. Public Health* 27, 297–322.
- Salvy, S.J., Bowker, J.W., Roemmich, J.N., et al., 2008. Peer influence on children's physical activity: an experience sampling study. *J. Pediatr. Psychol.* 33 (1), 39–49.
- Salvy, S.J., Roemmich, J.N., Bowker, J.C., Romero, N.D., Stadler, P.J., Epstein, L.H., 2009. Effect of peers and friends on youth physical activity and motivation to be physically active. *J. Pediatr. Psychol.* 34 (2), 217–225.
- Salvy, S.J., Bowker, J.C., Germeroth, L., Barkley, J., 2012a. Influence of peers and friends on overweight/obese youths' physical activity. *Exerc. Sport Sci. Rev.* 40 (3), 127–132.
- Salvy, S.J., de la Haye, K., Bowker, J.C., Hermans, R.C., 2012b. Influence of peers and friends on children's and adolescents' eating and activity behaviors. *Physiol. Behav.* 106 (3), 369–378.
- Salvy, S.J., Roemmich, J.N., & Paulch, R. Ecological Analysis of Youth Physical Activity: A Methodology Consideration. University at Buffalo. Buffalo (Unpublished Manuscript).
- Sanders, G.J., Peacock, C.A., Williamson, M.L., Wilson, K., Carnes, A., Barkley, J.E., 2014. The effect of friendship groups on children's physical activity: an experimental study. *J. Behav. Health* 3, 95–100.
- Santos, R., Mota, J., Okely, A.D., et al., 2014. The independent associations of sedentary behaviour and physical activity on cardiorespiratory fitness. *Br. J. Sports Med.* 48 (20), 1508–1512.
- SAS, 2013. SAS 9.4. 9.2 ed. SAS Institute Inc., Cary, NC.
- Sawka, K.J., McCormack, G.R., Nettel-Aguirre, A., Blackstaffe, A., Perry, R., Hawe, P., 2014. Associations between aspects of friendship networks, physical activity, and sedentary behaviour among adolescents. *J. Obes.* 2014, 632689.
- Schuster, R.M., Mermelstein, R.J., Hedeker, D., 2016. Ecological momentary assessment of working memory under conditions of simultaneous marijuana and tobacco use. *Addiction* 111 (8), 1466–1476.
- Simmons, D., McKenzie, A., Eaton, S., et al., 2005. Choice and availability of takeaway and restaurant food is not related to the prevalence of adult obesity in rural communities in Australia. *Int. J. Obes.* 29 (6), 703–710.
- Smedley, B., Amaro, H., 2016. Advancing the science and practice of place-based intervention. *Am. J. Public Health* 106, 197.
- St George, S.M., Wilson, D.K., 2012. A qualitative study for understanding family and peer influences on obesity-related health behaviors in low-income African-American adolescents. *Child Obes.* 8 (5), 466–476.
- Stock, S., Miranda, C., Evans, S., et al., 2007. Healthy Buddies: a novel, peer-led health promotion program for the prevention of obesity and eating disorders in children in elementary school. *Pediatrics* 120 (4), e1059–e1068.
- Storch, E.A., Milsom, V.A., Debraganza, N., Lewin, A.B., Geffken, G.R., Silverstein, J.H., 2007. Peer victimization, psychosocial adjustment, and physical activity in overweight and at-risk-for-overweight youth. *J. Pediatr. Psychol.* 32 (1), 80–89.
- Vanhelst, J., Beghin, L., Turck, D., Gottrand, F., 2011. New validated thresholds for various intensities of physical activity in adolescents using the Actigraph accelerometer. *Int. J. Rehabil. Res.* 34 (2), 175–177.
- Voorhees, C.C., Murray, D., Welk, G., et al., 2005. The role of peer social network factors and physical activity in adolescent girls. *Am. J. Health Behav.* 29 (2), 183–190.
- Wang, X., Guo, X., He, M., Zhang, H., 2011. Statistical inference in mixed models and analysis of twin and family data. *Biometrics* 67 (3), 987–995.
- Weimann, H., Bjork, J., Rylander, L., Bergman, P., Eiben, G., 2015. Neighborhood environment and physical activity among young children: a cross-sectional study from Sweden. *Scand. J. Public Health* 43 (3), 283–293.
- Zhang, J., Tong, L., Lamberson, P.J., Durazo-Arvizu, R.A., Luke, A., Shoham, D.A., 2015. Leveraging social influence to address overweight and obesity using agent-based models: the role of adolescent social networks. *Soc. Sci. Med.* 125, 203–213.