

I. Introduction

A. Nature of the research problem

Nearly half of American youth are not physically active on a regular basis. With obesity emerging as a major public health crisis, physical activity and sedentary behaviors are key targets for altering energy balance in preventing and reducing obesity. Health behaviors are multidimensional and form multiple patterns within individuals. However, most studies to date look at one dimension of physical activity. Few studies have studied the co-varying patterns of physical activity and inactivity within an individual, its changes over time, and its association with overweight. Understanding how health behaviors co-vary and how health behavior patterns relate to overweight will significantly aid the development of appropriate interventions that promote physical activity and harness the overweight epidemic.

Social ecological models suggest that conditions in the social and physical environment in addition to individual factors play important roles in health behavior change. The role of social environments in this process is an understudied area. While emerging evidence shows that neighborhood physical and social environments have independent effects on physical activity, there has been little research from longitudinal studies identifying the long-term effects of neighborhood environments on physical activity and overweight among the adolescents who are transitioning from adolescence to young adulthood. Due to lack of scientific evidence on the importance of environments on health and health behaviors, most health promotion and behavior change interventions were created in the decontextualized manner that pays little attention to the features and influence of area.

B. Purpose, scope, and methods of the investigation

In this study, we filled these gaps by conducting two analyses using the data collected by the National Longitudinal Study of Adolescent Health (Add Health). Add Health is one of the largest longitudinal studies of a representative sample of adolescents in the United States.

In the first analysis, we used the latent class analysis to examine the co-varying patterns of physical activity and sedentary behaviors at adolescence. After identifying the co-varying patterns, we studied the long-term maintenance of these two behaviors as adolescents transitioned to young adulthood. Logistic regression models were used to determine the impact of these class profiles at adolescence on the likelihood of meeting national physical activity recommendations and exceeding screen time guidelines in young adulthood. A manuscript was developed based on this analysis and was accepted for publication.¹

In the second analysis, we tested whether meeting moderate to vigorous physical activity (MVPA) guidelines (≥ 5 bouts of MVPA per week) and spending excessive screen time (≥ 2 hours per day) were associated with perceived and structural neighborhood conditions. The data came from Wave 1 of Add Health ($n=13,668$ adolescents). Perceptual domain of neighborhood factors was captured by three summary variables (i.e., acquaintance, informal control, and public nuisance) measured at the individual level and at census tract level. Using nine census measures for the neighborhood, we derived three structural neighborhood factors: 1) concentrated poverty measure; 2) immigrant concentration; and 3) residential stability. Multilevel logistic regression models were used to examine the associations between these neighborhood factors and adolescents' physical activity and sedentary behaviors after controlling for potential confounders. This manuscript was completed and its main results were presented at the Annual

Conference of Active Living Research (February 18-20, 2009, San Diego, CA). The manuscript was submitted for publication and it is in revision and resubmission stage.²

During our project period, we modified the scope of our work slightly because we noticed that one published study and one unpublished doctoral dissertation have worked on the same hypotheses proposed in our original proposal.³⁻⁴ Thus to make our work publishable, we focused only on the original hypotheses that were not addressed in the literature. We did not explore the associations of physical activity and sedentary behavior co-varying patterns in adolescence with obesity in young adulthood.

C. Nature of the findings

In analysis 1, different from investigator-specified patterns (i.e., the combinations of categorical levels of physical activity and sedentary behaviors), we used person-oriented latent class analysis (LCA) approach, which provides a rich profile on the types of activities that each class participate in. LCA identified five gender-specific co-varying classes between physical activity and sedentary behaviors. These five classes were labeled as low physical activity (PA)/low sedentary behaviors (SED), moderate (Mod) PA/high (HI) SED, Mod PA/low SED, HI PA/low SED, and HI PA (except skating/biking)/low SED. Compared to low PA/low SED, males and females in Mod PA/low SED, HI PA/low SED, and HI PA (except skating / biking)/low SED classes had increased odds of meeting MVPA recommendations in young adulthood. Mod PA/HI SED had higher odds of exceeding screen time guidelines in young adulthood (adjusted odds ratio (AOR) for females: 1.67, 95% CI: 1.00, 2.81; AOR for males: 3.31, 95% CI: 1.80-6.09). Our results suggest that compared to those in the classes with a high level of physical activity, those who reported the lowest level of overall physical activity were not spending any more hours on screen while they were less likely to meet the MVPA recommendations. To our surprise, we only found one high sedentary subgroup with moderate physical activity but no other highly sedentary patterns such as low PA/HI SED or HI PA/HI SED which were found in a British study and would likely to be defined groups in investigator-specified patterns. To our knowledge, this is the first analysis using LCA to examine these behaviors in a large, nationally-representative cohort.

In analysis 2, we found that at individual level, the perceptions of neighborhood condition such as acquaintanceship and informal control were positively associated with meeting the MVPA guideline but not associated with spending excessive screen time. At the census tract level, compared to the low level of each variable, high or medium informal control or high concentrated poverty were associated with lower odds of meeting the MVPA guidelines after adjusting for socio-demographic characteristics. Also at the census tract level, high public nuisance, high immigrant concentration, and high residential stability were positively associated with spending excessive screen time among adolescents compared to the lowest levels, while the middle level acquaintanceship was negatively associated with spending excessive screen time among adolescents. Our findings suggest that both perceptual and structural neighborhood factors should be considered to understand adolescents' physical activity and sedentary behaviors.

II. Review of the Literature

Prevalence and benefits of physical activity. Physical activity has many beneficial health effects, including weight maintenance and numerous other health outcomes.⁵⁻⁶ Despite evidence of significant health benefits from even moderately intense activity, nearly half of American youths aged 12-21 years are not physically active on a regular basis.⁷ With obesity emerging as

a major public health crisis, physical activity and sedentary behaviors are key targets for altering energy balance in preventing/reducing obesity.

Physical inactivity and its adverse effects on health. Historically, physical activity has received more attention than physical inactivity. Inactivity behaviors include television viewing, reading, working at a computer, talking with friends or on the telephone, driving a car, meditation, and lying in bed awake.⁸ Sedentary behaviors are notably high among adolescents.⁹ Recent rapid increases in juvenile obesity have received a great deal of attention in the scientific and popular press and have been attributed partly to television viewing, computer games and other sedentary behaviors. The adverse health effects of inactivity may be as significant as the beneficial health effects of vigorous activity. A number of studies have shown that physical inactivity is recognized as an independent risk factor for the development of obesity¹⁰⁻¹¹ and a few major chronic diseases such as diabetes,¹¹⁻¹² coronary artery disease, and cardiovascular mortality.⁵

Rationale for studying physical activity (PA) and physical inactivity (PIA) patterns. Many have considered sedentary behavior to be at one end of the physical activity continuum. One would view sedentary behaviors as competitors for adolescent's time in that sedentary behaviors would displace physical activity. However, evidence show that PA and PIA are weakly associated or unrelated.¹³⁻¹⁷ Differential determinants of PA and PIA indicate that they are conceptually and empirically distinct.^{9, 18}

The association between PA and PIA varies by the type of sedentary behaviors. The association between TV viewing and PA is inconsistent. Some found that TV viewing was inversely associated with PA among adolescents,^{13, 19-22} while others found that TV viewing was not associated with decreased PA.²³⁻²⁵ Computer use was shown to be associated with higher level of PA among adolescents.^{19, 26} Feldman et al.²⁵ found that adolescents who spent time "learning" and engaging in "academic" pursuits (such as reading, or doing homework and working on computers) are more likely to make time for PA. In contrast, the time spent in more "nonacademic" pursuits, like watching TV, playing video games, was not associated with time spent doing PA. It is possible that some children are more capable of managing their time to include both PA and sedentary pursuits, or that those who are not physically active choose not to be, regardless of whether they watch TV.

Segmenting target populations into homogeneous groups can help to improve the reach, utilization, and effectiveness of health interventions. The multidimensional patterning of health behaviors has gained recognition, particularly regarding diet and other behaviors.²⁷⁻³¹ Nelson et al. were the first to study the co-varying patterning of PA/PIA using cluster analysis and using the data from Add Health.³²⁻³³ Nelson et al. examined 16 PA and sedentary behavior-related variables into their models. These variables included items that were proximate correlates of PA rather than actual PA (e.g., school's physical education, the likelihood of making own TV decisions, playing sport with a parent, and using a recreation center). Consequently they ended up with 7 clusters. The large number of clusters makes it impractical for intervention development and for studying patterns of change over time.

Tracking PA/PIA patterns during the transitional period. Both cross-section studies and prospective studies³⁴⁻³⁵ support the tracking of activity levels over time, indicating that sport activities during childhood and youth may form the foundation for activity habits in the future. Gordon-Larsen et al.⁹ found that a greater proportion of females, particularly Hispanics and black females, failed to achieve recommended 5 or more bouts of moderate physical activity per

week at adolescence and into adulthood. Sedentary behaviors appear to track better than physical activity from adolescence to young adulthood.³⁶

Because the transition from adolescence to young adulthood marks a striking decline in physical activity³⁶⁻³⁹ and an increase in physical inactivity,⁴⁰ it is particularly important to understand the transition of PA and PIA profiles during this critical period. So far physical activity and sedentary behaviors have been studied as independent actions⁴¹ in most cases and rarely as co-varying behaviors.³²⁻³³ Little is known about how the transition of PA and PIA profiles is associated with overweight status in young adulthood.

Social environmental factors: understudied determinants of PA/PIA and overweight status. Environmental variables, part of the complex web of causation that leads to healthful and unhealthful behaviors, are recently receiving increased attention. Emerging evidence shows neighborhood physical environments such as perceptions on aesthetic, functionality and traffic have independent effects on physical activity mainly among adult population.^{29, 42-48} The role of social environments in this process has received less attention. Studies found that supportive familial environment (such as parental PA, sibling PA, parents support, direct help from parents, support from significant others) is associated with PA.⁴⁹ Individuals with low social participation had over twice the odds of low PA compared to those with high social participation.⁵⁰ Also recent studies found the support from peers is consistently related the participation of physical activity.⁵¹⁻⁵⁴ Findings on the role of neighborhood safety on physical activity are less consistent. Some studies found that neighborhood safety was positively associated with the participation of physical activity among adolescents,⁵⁵⁻⁵⁶ while others found neighborhood safety was not related to PA.⁵⁷⁻⁵⁹ Although more limited, there is evidence of a positive association between area of residence and obesity⁶⁰ and with explicit findings of the impact of a weakened social context (indicated by high residential turnover and female-headed households living in poverty) and poor diet and obesity.⁶¹

Social cohesion defined as the norms of trust and reciprocity shared among neighbors has received little attention. McKay et al.⁶² found that the state-level mutual aid and social trust were significantly related to not meeting PA recommendations. We hypothesize that adolescents who live in a more cohesive community and safe neighborhood will be more active because they have access to community open spaces and transit systems for both recreational and transportation purposes.

III. Study Design and Methods

A. Study design.

Both cross-sectional and longitudinal analyses were used to fit the purposes of our research. Data from a nationally representative survey, the National Longitudinal Study of Adolescent Health (Add Health) were used. The Add Health was designed to examine the causes of health-related behaviors.

B. Population studied

For Analysis 1, we used the data from 13,339 adolescents (6,563 boys and 6,776 girls) who were interviewed in both wave 1 and II to develop the co-varying patterns of physical activity and sedentary behaviors. We excluded 100 adolescents who had any type of physical disabilities and 129 females who were pregnant at the interview time in either Wave I or II. To examine the long-term maintenance of physical activity and sedentary behaviors from adolescence to young

adulthood, we restricted our sample to the participants who were interviewed in all three waves of Add Health (8,254 for physical activity outcome, 8,245 for sedentary behavior outcome).

For analysis 2, we included 13,668 adolescents who were interviewed in Wave I of the Add Health after excluding 110 adolescents who had any type of physical disability, 2,496 adolescents with missing values in any neighborhood variables, and 2,200 adolescents with missing values in covariates in our final models.

C. Sample selection

Add Health surveyed a sample of 20,745 students in grades 7-12 (ages: 11-21) in the United States. The Add Health included a core sample and additional subsamples of selected ethnic and other groups (over 20,000 adolescents) in 1994-1995 (Wave I). All eligible adolescents who would have been in school during 1996 were re-interviewed in 1996. The follow-up rate was 88% (Wave II). In 2001-2, 15,197 participants who were eligible in Wave I were re-interviewed (Wave III). More details about the survey design, sampling frame, and interview methods have been described elsewhere⁶³ and on the study website (<http://www.cpc.unc.edu/addhealth>).

D. Instruments used

Measures of physical activity and sedentary behaviors. In the in-home interviews (Waves I & II), adolescents were asked to report their daily physical activities and sedentary behaviors using a 7-day recall questionnaire. Daily physical activities were assessed in five questions. Each was worded as such, “during the past week, how many times did you ...” and followed by 5 types of activity: 1) housework; 2) hobbies; 3) skating/biking; 4) active sports, and 5) exercise. The following scores were assigned to each category for these questions: 0 (not at all), 1.5 (1 or 2 times), 3.5 (3 or 4 times), and 5 (5 or more times). The same questions for physical activities were asked in Waves I and II. Wave III added new activities applicable to young adults such as drama, singing, shopping for fun in the hobby group etc.

Activities were translated into metabolic equivalent (MET) values. According to the Compendium,⁸ housework (except cleaning) and hobbies are light activities that cost one to three METs, while skating/biking, active sports, and exercise cost five to eight METs. Add Health lumped activities with similar METs into one question as shown above, thus in our analysis MVPA included activities with 5-8 METs, instead of ≥ 3 METs used in some publications.⁶⁴ Using available information, we developed a measure of meeting the physical activity recommendations defined as participating in five or more bouts of MVPA per week. To better understand the usual behavior patterns for adolescence, we created an average of Waves I and II for the meeting MVPA recommendations measure (over 99.9% of the sample).

Sedentary behaviors were assessed in all waves of Add Health via three questions. Each was worded as such “How many hours a week do you ...” and followed by activities like watching television and videos, and playing video or computer games. Wave III added additional questions applicable to young adults, for example, using a computer for surfing the Web, exchanging email, or participating in a chat room. Answers to these questions were summed to create the total screen time (hours/week) that adolescents spent on sedentary activities. An average of total hours spent in sedentary activities in Waves I and II was calculated to assess the usual sedentary behavior in adolescence. The total hours in sedentary activities in Wave III was used to assess their level of sedentary behaviors in young adulthood. Using national guidelines,⁶⁵⁻⁶⁶ we defined exceeding recommended total screen time as > 2 hours of screen time per day.

Measures of perceived neighborhood condition. Perceptual domain of neighborhood factors was captured by three summary variables (i.e., acquaintanceship, informal control, and public nuisance) measured at the individual level. In this study, acquaintanceship measure was based on adolescents' responses while informal control and public nuisance were on parents' responses. Acquaintanceship,⁶⁷ or how well their neighborhood's residents knew each other, was assessed using three questions from the In-home questionnaire. They were: 1) "You know most of the people in your neighborhood"; 2) "In the past month, you have stopped on the street to talk with someone who lives in your neighborhood"; and 3) "People in this neighborhood look out for each other." All answer options are "1=True; 2=False." A summary score of answers to these questions was created that higher score indicate high level of acquaintanceship.

Informal control and public nuisance were measured using responses to questions in the Parent Questionnaire. Informal control, or "shared expectation for the supervision and protection of local youths (p. 699)"⁶⁸ was measured based on two questions: 1) "If you saw a neighbor's child getting into trouble, would you tell your neighbor about it?"; and 2) "If a neighbor saw your child getting into trouble, would your neighbor tell you about it?" Parents answered these questions using 5-point Likert scale (i.e., 1 = definitely would; 5 = definitely would not), which were reverse-coded and, then, aggregated into a mean scale.

Public nuisance was based on parent's response to three questions: 1) "In this neighborhood, how big a problem is litter or trash on the streets and sidewalks?"; 2) "In this neighborhood, how big a problem are drug dealers and drug users?"; and 3) "How much would you like to move away from this neighborhood?" Three-point Likert scales, "1 = no problem at all; 2 = a small problem; 3 = a big problem" for the first two questions and "1 = not at all; 2 = a little; 3 = very much" for the last, were used for parent's response, which were aggregated into a mean scale of public nuisance.

To capture the contextual effects of these neighborhood perception,⁶⁷ each of these three individual level measures of perceptual domain of neighborhood factors were further aggregated by 1990 census tract to create neighborhood level measures of perceptual domain. These aggregated variables measure macrolevel or contextual aspect of the neighborhood perception measured in individual level. An average score for each 1990 census tract was calculated using the scores of Add Health study participants living in the same census tract. This resulted in three census tract level perceptual domain neighborhood factors (i.e., acquaintanceship, informal control, and public nuisance variables).

Measures of structural neighborhood condition. Nine census measures⁶⁷ were selected based on theories and previous studies and subject to principal components analysis to create the three structural neighborhood factor scores.⁶⁸ Concentrated poverty measure was measured by the proportions of households with income below poverty level, with public assistance, single female headed households, and unemployment rate. Immigrant concentration score was calculated using the proportions of Hispanic, foreign born, and residents with limited English skills. Residential stability score was assessed by the proportion of households living in the same house for 5 years or longer and the proportion of housing occupied by owners.

Because our neighborhood contextual measures were created based on multiple items, each measure used a different scale. To facilitate the interpretation of results, both the perceptual and structural domain neighborhood factor scores were divided into terciles based on the number of respondents in each category.

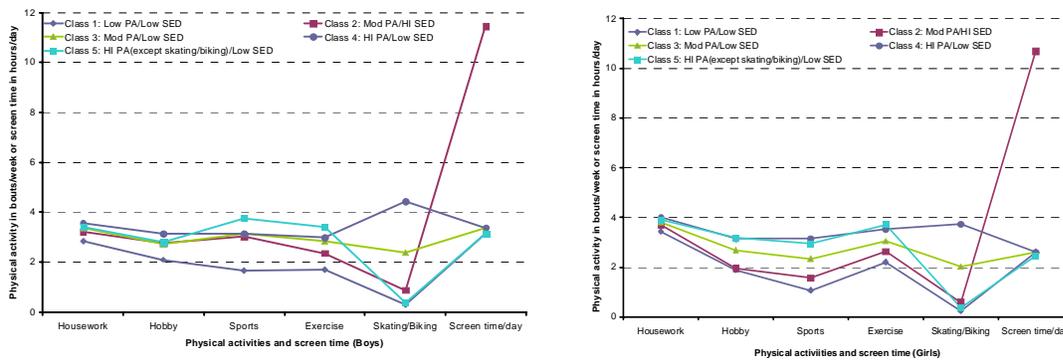
E. Statistical techniques employed

See section I.C above.

IV. Detailed Findings

A. Analysis 1.

The LCA identified 5 gender-specific co-varying patterns of physical activity and sedentary behaviors among adolescents. The co-varying patterns looked similar for males and females although the absolute frequencies of the behaviors were different. For simplicity we used the same labels to characterize these patterns for both males and females. Although the class profiles in each gender were very similar, the mean frequencies of specific activities differed by gender. Across different classes, females reported higher frequencies in household chores than males. Males appear to have a higher frequency of sports participation than females, while females in each class appear to have a higher frequency of exercise than males. Finally mean daily screen time was higher among males than females in each class (see Figures 1 and 2).



Figures 1 and 2. Co-varying patterns of physical activity and sedentary behaviors among adolescents.

The proportion of children classified into each class also varied by gender. For males, the top three classes were low PA/low SED (29.9%), HI PA (except skating/biking)/low SED (29.2%), and Mod PA/low SED (28.3%). For females, more than half of them (55.7%) were in low PA/low SED class, followed by Mod PA/Low SED (18.3%), and HI PA (except skating/biking)/low SED (18.2%). Fewer females were in HI PA/low SED (4.9%) and Mod PA/Hi SED (3.0%) than males (8.4%, 4.2% respectively).

These classes varied by socio-demographic characteristics. Adolescents in low PA/low SED class were older. Females in low PA/low SED were more likely to be Hispanics than females in Mod PA/low SED and HI PA/low SED classes. Adolescents in Mod PA/Hi SED class were more likely to be black (35% for males, 50% for females), come from low income families, and almost all of them were born in the US. Adolescents in Mod PA/low SED class were mainly white (68% for males, 72% for females). In the female sample, the Mod PA/low SED class had a lower proportion born in the US (93%) as compared to the Mod PA/Hi SED and HI PA/low SED. Adolescents in HI PA/low SED class were younger (males only) and mainly white (78% for males, 83% for females). Adolescents in HI PA (except skating)/low SED class were almost all in school.

Compared to low PA/low SED, males and females in Mod PA/low SED, HI PA/low SED, and HI PA (except skating / biking)/low SED classes had increased odds of meeting MVPA recommendations in young adulthood. Mod PA/Hi SED had higher odds of exceeding screen

time guidelines in young adulthood (adjusted odds ratio (AOR) for females: 1.67, 95% CI: 1.00, 2.81; AOR for males: 3.31, 95% CI: 1.80-6.09).

B. Analysis 2.

Neighborhood characteristics and physical activity. After controlling for the effects of gender, race/ethnicity, age, parental education, in school status, nativity status, region, and household income, adolescents with the middle (adj. OR = 1.32, $p < .001$) or the highest (adj. OR = 1.80, $p < .001$) tertile of neighborhood acquaintanceship were more likely to meet the MVPA guideline than those with the lowest tertile. Also, adolescents of parents with the highest tertile of perceived informal neighborhood control compared to the lowest were more likely (adj. OR = 1.11, $p = .030$) to meet the MVPA guideline.

At the census tract level, adolescents living in the highest informal control tertile neighborhood compared to the lowest tertile were less likely to meet the MVPA guideline (adj. OR = 0.86, $p = .010$). For structural domain neighborhood characteristics, adolescents living in the middle (adj. OR = 0.89, $p = .034$) or the highest (adj. OR = 0.82, $p = .006$) tertile neighborhood in its concentrated poverty measure compared to the lowest tertile were significantly or marginally significantly less likely to meet the MVPA guideline.

Neighborhood characteristics and sedentary behaviors. At the individual level, none of the neighborhood perceptual domain variables were associated with odds of spending excessive screen time adjusting for covariates. On the contrary, at the neighborhood level, adolescents living in the highest average public nuisance tertile neighborhood (adj. OR = 1.19, $p = .010$) or the highest immigrant concentration tertile neighborhood (adj. OR = 1.17, $p = .037$) were more likely to spend excessive screen time compared to the lowest tertile of the corresponding variables. Adolescents living in the middle perceived acquaintanceship tertile neighborhood were less likely to spend excessive screen time compared to the adolescents living in the lowest tertile neighborhood (adj. OR = 0.89, $p = .049$).

V. Discussion and Interpretation of Findings

A. Conclusions to be drawn from findings (with reference to data supporting each).

Based on our results presented above, the following conclusions can be made.

- Analysis 1: There are five distinct gender-specific co-varying patterns of physical activity and sedentary behaviors among adolescents based on the data from Add Health. The most prevalent class for males is low PA/low SED and HI PA (except skating)/low SED and for females is low PA/low SED. The least prevalent class is Mod PA/HI SED for both males and females.
- Analysis 1: Compared to low PA/low SED, adolescents in mod PA/low SED, HI PA/low SED, and HI PA (except skating / biking)/low SED classes had increased odds of meeting MVPA recommendations in young adulthood. Those in mod PA/HI SED had higher odds of exceeding screen time guidelines in young adulthood.
- Analysis 2: meeting MVPA guideline was positively associated with parents' perception of higher neighborhood informal control and adolescents' perception of higher neighborhood acquaintanceship at individual level, and higher census tract average perception of acquaintanceship and lower concentrated poverty at the neighborhood level.

- Analysis 2: Parents' perception of higher public nuisance and informal control in both individual and census tract level and higher census tract level concentrated poverty were associated with increased odds of adolescents' spending excessive screen time in bivariate relationship. After the adjustment for covariates and other neighborhood factors, none of the individual level perception variables were significant and only the census-tract level perceptual (i.e. public nuisance, acquaintance) and structural (residential stability, immigrant concentration) neighborhood factors were significantly associated with excessive screen time. The results also indicate that, after controlling for individual level socio-economic factors, neighborhood level measures of perceptual and structural factors are more important correlates of spending excessive screen time than individual level perception of their neighborhood.

B. Explanation of study limitations

- One limitation of this study is the use of self-reported measures in activity and sedentary behaviors on a limited set of activities. We also lack of data to quantify meeting MVPA recommendations such as the length of bouts, inability to distinguish moderate and light intensity physical activity with METs score less than 5.
- Add Health was designed to be a representative sample of adolescents at baseline in the US. However, due to sample attrition from Wave I to Wave III and additional deletion due to missing values, our analytic sample may not be nationally representative.

C. Comparison with findings of other studies

Compared with a published study using cluster analysis, we identified a smaller number of meaningful classes of the co-varying patterns of physical activity and sedentary behaviors for each gender. Consistent with person-oriented LCA approach, we confirmed that PA and sedentary behaviors should be explored as a holistic profile rather than separate variables. To our knowledge, our study is the first analysis using LCA to examine PA and sedentary behaviors in a large, nationally representative cohort. Also consistent with prior literature, we found that screen time tracked better than physical activity from adolescence to adulthood.

The main focus of previous studies on neighborhood factors and PA is placed on the understanding of physical, or built environment and its association with PA, sedentary behaviors, and/or obesity. Very few studies have paid attention to the perceptual neighborhood factors. Thus our study was unique and innovative in terms of including a comprehensive set of both structural and perceptual factors of neighborhood conditions as the predictors for adolescent's physical activity and sedentary behaviors and considering them at both individual and neighborhood levels. Different from a prior study which used the data from Fragile Families and Children's Well-being, we found that only census tract level measure of neighborhood nuisance, not the individual level measure is significantly associated with screen time.

D. Possible application of findings to actual MCH health care delivery situations (including recommendations when appropriate)

Nearly half of American youth are not physically active on a regular basis. With obesity emerging as a major public health crisis, physical activity and sedentary behaviors are key targets for altering energy balance in preventing/reducing obesity. Our findings will definitely contribute to the prevention and reduction of obesity epidemic through targeting

physical activity and sedentary behaviors. First, our confirmation that health behaviors (PA and PIA) covary will provide insights for the development of multifactorial prevention strategies. Segmenting target population into homogenous groups can help to improve the reach, utilization, and effectiveness of health interventions. Second, our findings suggest that understanding of perceptual and structural neighborhood factors on physical activity and sedentary behaviors is a promising factor with the potential of high impact. By targeting the community, a greater percentage of the underactive population may be reached with potentially lower costs per person. Due to lack of scientific evidence on the importance of environments on health and health behaviors, most health promotion and behavior change interventions were created in the decontextualized manner that pays little attention to the features and influence of area.

E. Policy implications

Our findings suggest that both physical activity and physical inactivity should be considered simultaneously in the prevention and alleviation of obesity epidemics among adolescents in the United States. These two behaviors co-vary that there is a need to understand its co-varying patterns in the design of effective interventions for the homogeneous subgroups of the population. Neighborhood conditions including both the perceptual and structural conditions are important factors in the policies and programs with the aim of increasing physical activity and reducing sedentary behaviors.

F. Suggestions for further research

For future studies, it is necessary to confirm the utility of LCA to identify co-varying patterns using different datasets and from different populations. More in-depth analysis of the psychosocial correlates (such as perceived benefits and barriers, attitudes, social support, and self-efficacy) especially as they relate to demographic differences in each class would be very useful for the design of effective interventions. To understand the perceptual neighborhood factors, it is important to elicit the information from both the parents and children and disentangle the relative contributions of these factors. Future studies should include more observations in each census tract to generate more representative neighborhood factors at census tract level.

VI. List of products (peer reviewed articles, books, chapters in books, master and doctoral dissertations, conference presentations, etc.).

Presentations

1. Kim, J., **J. Liu**, N. Colabianchi, A. Ortaglia, R. Pate. Neighborhood Effects on Adolescent's Physical Activity and Sedentary Behaviors. *Annual Conference of Active Living Research*, Feb. 18-20, 2009, San Diego, CA. Poster.

Peer-reviewed manuscripts

1. **Liu, J.**, J. Kim, N. Colabianchi, A. Ortaglia, R. Pate. Co-varying patterns of physical activity and sedentary behavior patterns among adolescents. *Journal of Physical Activity and Health* (in press)
2. Kim, J., **J. Liu**, N. Colabianchi, A. Ortaglia, R. Pate. The Role of Perceived and Structural Neighborhood Conditions on Adolescent's Physical Activity and Sedentary Behaviors (Revise and resubmission).

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