The Implications of Neighborhood Crime and Parents' Perceptions of Crime on Children's Physical Activity and Resulting Health Outcomes and Health Care Use

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A dissertation
submitted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

University of Washington

2012

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Program Authorized to Offer Degree:
School of Public Health
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Abstract

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Physical activity is a modifiable health behavior that can impact health outcomes. Chapter 2 examined children's baseline weight and physical activity and follow-up health care utilization and school absences. Meeting physical activity recommendations was negatively associated with overweight/obese status, and more overweight/obese children than healthy weight children had at least one health condition. Baseline physical activity and weight did not predict health care use or school absences at 2-year follow-up. Chapter 3 determined where children ages 6-11 were physically active using time-stamped accelerometer data and parent-reported place logs. Children spent most time and did most physical activity at home and school. Although neighborhood time was limited, this time was more proportionally active than time in other locations (e.g., 42.1% of time in neighborhood vs. 18.1% of time at home). Children with any neighborhood-based physical activity had higher average total physical activity. Chapter 4

evaluated how five crime measures were interrelated and which crime measures were related to children's total and neighborhood physical activity. We found positive correlations between parents' general crime & disorder perceptions and: neighborhood incivilities and stranger danger perceptions; parent-reported prior crime victimization and: neighborhood incivilities, general crime & disorder and stranger danger perceptions. Higher census block group-level police-reported crime was associated with less child total and neighborhood physical activity. Using 2003-2004 National Health and Nutrition Examination Survey cross-sectional data, Chapter 5 examined associations between physical activity and cardiorespiratory fitness and body adiposity. We also examined whether these relationships differed depending on how physical activity was measured: including 8-10 minute bouts or every minute. Positive associations between physical activity and cardiorespiratory fitness were found for boys 12-19 years and adults 20-49 years. Negative associations were found between physical activity and body adiposity for girls 12-19 years and adults 20-49 years. We found no significant differences between how physical activity was measured and its relationship with the two health outcomes. We demonstrated that meeting physical activity recommendations is significantly related to children's, adolescents', and adults' positive health outcomes. Furthermore, a child's neighborhood is a valid location for physical activity policy and interventions, and crime may be a worthwhile target.

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Chapter 1: Introduction

Overview

The goal of this dissertation is to inform physical activity policy and interventions to improve population physical activity levels, particularly in youth, to prevent negative health consequences and excess health care use in childhood and adulthood. Chapters 2 through 4 examine relationships between physical activity, neighborhood factors and health care use in children ages 6-11 years old, and Chapter 5 examines physical activity and health outcomes in adolescents ages 12-19 years old and adults ages 20-49 years old.

Background & Significance

Physical activity is any movement of the body that results in some form of energy expenditure. Different types of physical activity are classified by their intensity, typically using the metabolic equivalent (MET) as a reference (Physical Activity Guidelines Advisory Committee, 2008). One MET is equivalent to the amount of energy expended at rest, and higher METs are indicative of higher energy expenditure. The Centers for Disease Control and Prevention recommend for adults 150 minutes a week of at least moderate intensity physical activity (i.e. 3+ METs) like brisk walking, combined with muscle-strengthening activities (CDC, 2008). Children and adolescents' recommendations are 60 minutes per day of physical activity (CDC, 2008; Secretary of Health and Human Services and Secretary of Education (SHHS&SE), 2000). For adults, meeting these recommendations is associated with several health benefits, such as reduced risk of cardiovascular disease, type 2 diabetes, obesity, and several types of cancer (Brown et al., 2003; Dubbert, 2002; Physical Activity Guidelines Advisory Committee, 2008). Immediate benefits of regular physical activity for children include improved

concentration and academic achievement, reduced symptoms of anxiety and depression, and in the long-term reduced risk factors for health concerns similar to those of adults (Physical Activity Guidelines Advisory Committee, 2008; Strong, et al, 2005).

With knowledge of these benefits in hand, how many US adults and children meet these recommendations? Using objective physical activity measures on a nationally representative sample, Troiano and colleagues estimated that less than 5% of adults, less than 10% of adolescents, and less than 50% of children currently meet their respective recommendations (Troiano, et al, 2008). It can be argued that many Americans are at risk for several health conditions, in part because of insufficient and inconsistent amounts of physical activity. One of the clearest examples of this risk is manifested in the rising levels of obesity for both adults and children. Childhood obesity is particularly concerning for public health officials because evidence suggests that not only is it associated with childhood health consequences (Freedman, et al, 2007; Must & Strauss, 1999), but it is predictive of obesity and health conditions in adulthood (Freedman, et al, 2007; Thompson, et al, 2007). Furthermore, childhood obesity is associated with higher health care utilization and costs (Estabrooks & Shetterly, 2007; Hampl, Carroll, Simon, & Sharma, 2007; John, Wenig, & Wolfenstetter, 2010). Increasing children's physical activity through policy and other interventions is needed to help reduce these negative health consequences in childhood and adulthood and excess health care use and costs.

Knowing *where* to intervene and create policies is just as important as knowing *how* to increase children's physical activity levels. More research is needed examining children's immediate environments and how context may influence their physical activity (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008). Some have argued that parents' perceptions of various

neighborhood factors also may influence children's physical activity (e.g. Weir, Etelson, & Brand, 2006). A particular neighborhood factor that is gaining attention is neighborhood safety from crime. Issues of crime and safety may be especially pertinent to children's physical activity, because children are seen as more vulnerable and through parent supervision and control may be precluded from moving freely through or being within areas perceived as unsafe. Knowledge of children's neighborhoods, how much activity they are getting and where they are getting it may elucidate best places to target children's physical activity interventions. Moreover, exploring children's neighborhoods would provide insight for built and social environment changes in that specific location, which may also encourage children to increase their activity in their neighborhood.

Based on previous study findings and subsequent recommendations, additional research is needed to address the following critical gaps: how children's weight is related to other health conditions and subsequent health care use; whether or not physical activity can mitigate this weight-health care use relationship for youth as previously demonstrated in adult studies; where children spend most of their time and how much of that time is active; and what the barriers and facilitators are that determine children's physical activity locations. These gaps in the literature are the primary focal points of this dissertation.

Aims of the Dissertation

Chapter 2, "The effect of children's weight status and physical activity on health care visits and school absences: Findings from an observational prospective cohort study," explores the question "Can meeting physical activity recommendations lessen the impact of weight status on health outcomes and health care use for children?" This study's primary aim is to examine the

relationship between 6-11 year old children's baseline weight status and physical activity levels and subsequent health care utilization measured at 2-year follow-up. The second aim examines the relationship between these baseline factors and number of school days missed because of illness measured at 2-year follow-up. Finding factors that may be related to preventing illness and subsequent missed school days is important to study, because there are both health and social consequences.

Chapter 3, "Children's objective physical activity by location: Cross-sectional findings," describes where children are active. The primary aim is to determine where children ages 6-11 years old accrue their physical activity using accelerometer and parent-reported place logs and to examine variations by age and sex, race/ethnicity, and household income. The second aim is to determine if there are demographic factors, parents' perceptions, and/or neighborhood factors that vary in children who accrue any physical activity in their neighborhoods compared to children who do not, and also to determine if average daily physical activity differs between children who are active in their neighborhoods relative to children who are not active in their neighborhoods. Knowledge of where children are active and facilitators and barriers to physical activity is important for policy and physical activity interventions (Foster & Giles-Corti, 2008), because it may lead to more informed policies about how and where to intervene and improve physical activity levels.

Chapter 4, "Associations between neighborhood crime, parents' safety perceptions, and children's physical activity," investigates how different measures of neighborhood crime are related, and whether any are any related to children's physical activity. The aims of this study are to provide a more comprehensive picture of neighborhood crime by determining how five

different crime measures are related and then to explore how any or all of these crime measures are related to children's overall physical activity, and physical activity that occurs exclusively in their neighborhood. Different measures of crime may not be correlated with one another, and they may also measure unique (and equally) important concepts that impact children's physical activity distinctively. Issues of crime and safety may be especially pertinent to children's physical activity, because parents' perceptions of crime may more directly influence children's neighborhood activity than actual crime levels (Badland et al, 2009; Carver et al, 2008).

Chapter 5, "Associations between physical activity, cardiorespiratory fitness and body adiposity in youth and adults using objective measures," examines the associations of physical activity with body adiposity and cardiorespiratory fitness in adolescents and adults using objective measures. Chapter 2 explores the immediate consequences of inactivity and heavier weight status in childhood; in Chapter 5 we explore two critical health consequences of being inactive in adolescence and adulthood. The primary aim is to examine the associations between physical activity and cardiorespiratory fitness and body adiposity. The secondary aim is to examine whether the relationships between physical activity and cardiorespiratory fitness and body adiposity differ depending on how physical activity is measured, either in 8-10 minute bouts or every minute of physical activity. For adults, research suggests health benefits can be gained from consistently engaging in physical activity on a daily basis, with additional evidence suggesting intervals of moderate activity should be at least 8-10 minutes in length to incur benefits (Blair, LaMonte, & Nichaman, 2004; CDC, 2008; Dubbert, 2002). The shortest length of time children can be active to accrue their 60 minute recommendation and resulting health benefits are unknown. Whether or not adults can still gain health benefits from even shorter

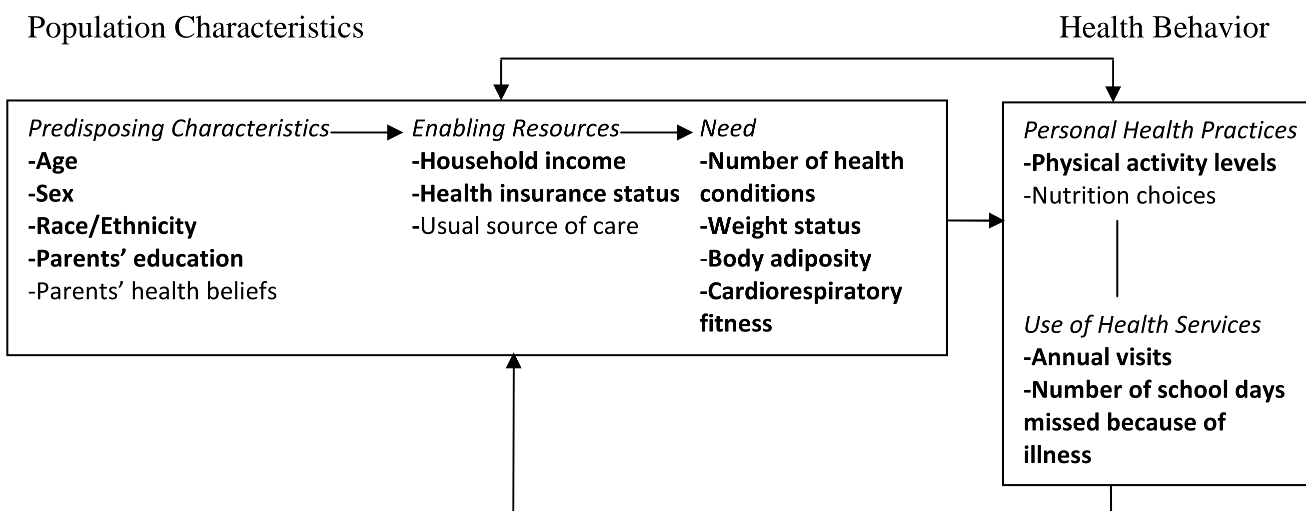
bouts of activity (i.e. less than 8-10 minutes) that accumulate to the daily recommendations is unknown. Cardiorespiratory fitness and body adiposity are important health outcomes to study in the context of physical activity, because they are the primary components indicated for an individual's overall health, cardiovascular health, and physical performance (Dishman, Washburn & Heath, 2004).

Conceptual Models

Chapters 2 and 5 are informed by Andersen's Behavioral Model of Health Services Use shown in Figure 1.1 (Andersen, 1995). This model was selected because it is one of the most widely used models in health services research. In this adapted model, feedback loops not only indicate a bidirectional relationship between population characteristics and health behavior, but that outcomes like health services use can affect subsequent need for care and other health behaviors such as physical activity and nutrition choices (Andersen, 1995). Population characteristics are further categorized into *predisposing characteristics* such as demographics (e.g. age, sex)*, enabling resources* including health insurance status and income*,* and *need for care,* with health conditions and other health status indicators like weight as primary examples of needs in this model. The variables studied in Chapter 2 and their respective categorization closely mirror several of the predisposing, enabling, need, and health behavior variables previously studied in Canadian adolescents and young adults (Ryan, Stewart, Campbell, Koval, & Thind, 2011). Although all variables proposed in the model are hypothesized to make contributions to health services use and school absences in children, we were not able to measure all of these variables. Variables that were measured in the current dissertation are indicated in bold.

In Chapter 2, the role of children's weight status (i.e. healthy weight vs. overweight/obese) is examined as both a direct and indirect influence via health conditions on children's health care use and school absences measured at 2-year follow-up. Children's physical activity is a proposed moderator of their weight status on health care use and school absences based on previous adult findings (Dogra, Baker, & Ardern, 2009). In Chapter 5, the relationships between the health behavior, physical activity and two needs (as defined by Andersen), body adiposity and cardiorespiratory fitness, are examined to better understand how they interact in adolescents and adults. These relationships are important to explore because of their potential impact in future health services use and other health outcomes.

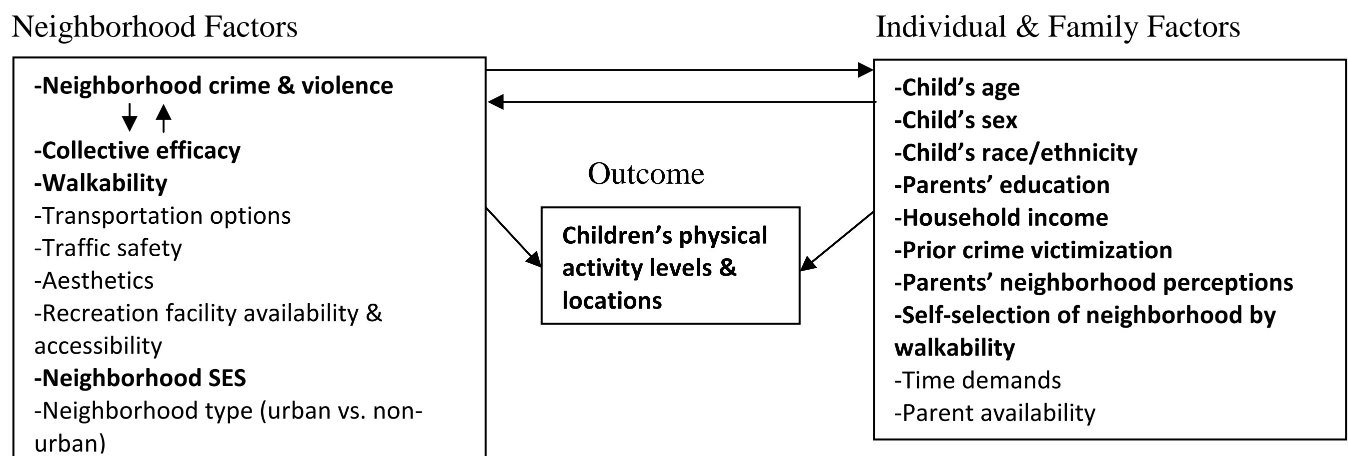
Figure 1.1. Conceptual Model for Chapters 2 and 5



Based on an extensive literature review, we created a socioecological model that informs Chapters 3 and 4 (Figure 1.2). This model proposes that neighborhood, family, and individual factors influence children's physical activity levels and locations. Additionally, neighborhood factors are proposed to influence individual and family factors such that the presence of various

neighborhood amenities and deterrents influence parents' subsequent perceptions (e.g. speeding cars may lead parents to conclude that their neighborhood has low traffic safety). In turn, individual and family factors also are proposed to influence the neighborhood, primarily through parents' self-selection of their neighborhood based on what they desire in a neighborhood (e.g. proximity to shops, public transportation options). Where a child is active and whether or not that child is active in his or her own neighborhood both are proposed to be influenced by the individual, family, and neighborhood factors in this conceptual model. Although not all of these factors were measured in the present dissertation, several were explored in Chapter 3. Chapter 4 provides an in-depth examination of neighborhood crime and its association between children's total physical activity and activity in their neighborhood. A detailed description of proposed associations and interactions in Figure 1.2 that were examined in Chapters 3 and 4 is presented next, where the concepts that were measured in the dissertation are in bold. The relationships between neighborhood crime, parents' perceptions of crime and children's physical activity are emphasized in the discussion below because of the in-depth exploration of these relationships in Chapter 4. It is acknowledged that concepts not measured in the dissertation remain potentially important factors for our outcomes based on our literature review. For brevity, though, these concepts are not discussed.

Figure 1.2. Conceptual Model for Chapters 3 and 4



Neighborhood-level Factors

Neighborhood Crime. Past research has supported both a direct negative relationship between neighborhood crime, violence, incivilities, and children's physical activity (Brown, Perez, Mirchandani, Hoelscher, & Kelder, 2008; Carver, Timperio, & Crawford, 2008; Foster & Giles-Corti, 2008; Gomez, Johnson, Selva, & Sallis, 2004; Lopez & Hynes, 2006; Loukaitou-Sideris, 2006; Loukaitou-Sideris & Eck, 2007; Williams & Green, 2001), as well as an indirect negative relationship through perceptions of crime and children's physical activity (Carver et al, 2008; Carver, Timperio, Hesketh, & Crawford, 2010; Committee on Environmental Health, 2009; Deforche, Van Dyck, Verloigne, & De Bourdeaudhuij, 2010; Duncan, Johnson, Molnar, & Azrael, 2009; Foster & Giles-Corti, 2008; Gomez et al, 2004; Kaczynski & Sharratt, 2010; Lopez & Hynes, 2006; Loukaitou-Sideris, 2006; Loukaitou-Sideris & Eck, 2007; Romero, 2005; Valentine & McKendrick, 1997; Weir, Etelson, & Brand, 2006; Williams & Green, 2001). Research remains mixed with some finding no relationship between crime and/or parents' perceptions of crime and children's physical activity (Babey, Hastert, Huang, & Brown, 2009; Kerr et al, 2006). Some have suggested that measurement differences may play a role in these mixed findings (Day, 2006; Foster & Giles-Corti, 2008), while others have noted little variation in their crime measures (Day, 2006; Hillier et al, unpublished; Pikora et al, 2006).

Collective Efficacy. A positive direct and indirect association is proposed between neighborhood collective efficacy and children's physical activity levels. Collective efficacy is the level of social cohesion and informal social control in the neighborhood (Sampson, Raudenbush, & Earls, 1997). It may influence not only physical activity but also crime rates (Lopez & Hynes, 2006; Sampson, et al, 1997; Sun et al, 2004; Williams & Green, 2001), while crime rates may

also in turn negatively affect collective efficacy (Bursik & Grasmick, 1993; Sampson, et al, 1997). This may indicate a potential confounding relationship. There is also evidence that collective efficacy and walkability of a neighborhood may reinforce one another (Kaczynski & Sharratt, 2010; McDonald, Deakin, & Aalborg, 2009; Williams & Green, 2001).

Walkability. The literature is strong with significant and positive associations between neighborhood walkability and physical activity for both adults (Day, 2006; Deforche et al, 2010; Greenberg & Renne, 2005; Kaczynski & Sharratt, 2010; Pikora et al, 2006; Rodriguez, Khattak, & Evenson, 2006; Saelens, et al, 2003; Sugiyama, Leslie, Giles-Corti, & Owen, 2009), and children (Day, 2006; Hillier, 2008; Kerr et al, 2006; Norman et al, 2006). In Chapters 3 and 4, a *physical activity environment* measure was created by using existing (e.g., parcel data on land use to create a land use mix measure) and study-created (e.g., park amenities and quality) information brought into a Geographic Information Systems (GIS). Neighborhoods were divided into two physical activity environment types that were either deemed supportive or unsupportive of physical activity.

Neighborhood SES is proposed to be indirectly associated with children's physical activity through the neighborhood factors included in the conceptual model and parents' perceptions of those characteristics, with those living in lower income neighborhoods disproportionately affected by lower rates of total physical activity (Neckerman et al, 2009; Roman, Knight, Chalfin, & Popkin, 2009). Additionally, evidence suggests that low income neighborhoods are associated with high crime rates (Sun, Triplett, & Gainey, 2004; Valentine & McKendrick, 1997; Williams & Green, 2001). There is also research to suggest a possible

interaction with neighborhood SES and walkability on children's active commuting to school (Kerr et al, 2006).

Family- and Parent-level Factors

Parent's Education & Household Income are both proposed to be positively associated with children's physical activity and negatively associated with parents' perceptions of crime (i.e. higher education and income, less fear or perception of crime) (Day, 2006; Hillier, 2008; Loukaitou-Sideris, 2006; Rodriguez et al, 2006; Valentine & McKendrick, 1997). Income may also be related to access to cars, however, potentially providing evidence for a negative association between household income and children's physical activity (Day, 2006; McDonald, 2008; Zhu & Lee, 2009).

Prior Victimization or prior victimization of someone known may play a mediating role in parents' perceptions of neighborhood crime. It has been suggested that those who previously have been victimized may have a stronger negative perception of neighborhood crime and violence than those who have never been victimized and do not know anyone personally who was previously been victimized (Bursik & Grasmick, 1993; Carver et al, 2008; Loukaitou-Sideris & Eck, 2007; Sun et al, 2004). Thus, actual neighborhood crime is proposed to have both a direct and indirect effect through prior victimization status on parents' perceptions of neighborhood crime.

Parents' perception of all neighborhood characteristics included in the model is a proposed mediator between the actual neighborhood characteristic and children's physical activity (although direct relationships are proposed between each characteristic and physical activity, too). The perceptions examined in Chapter 3 are of *traffic safety*, *aesthetics*, *recreation*

facility availability, *bike & pedestrian infrastructure*, and three measures of walkability: *land use mix access*, *land use mix diversity*, and *street connectivity*. Perceptions of *general crime & disorder* and *stranger danger* are explored in both Chapters 3 and 4. Some have proposed that perceptions of varying neighborhood characteristics may in fact play the more influential role between actual environmental characteristics and children's physical activity levels, particularly with neighborhood crime levels (Day, Anderson, Powe, McMillan, & Winn, 2007; Hillier, 2008; Hillier et al, unpublished; Pikora et al, 2006).

Self-selection continues to be a major concern in the built environment literature as it relates to physical activity, where people who prefer to be active self-select into neighborhoods that accommodate this (McDonald et al, 2009; Saelens et al, 2003; Williams & Green, 2001). Self-selection is not always in the individual's control, though, as some may desire to live in an activity-promoting neighborhood but may not have the financial means necessary to live there. Handy and colleagues have found evidence to support that neighborhood characteristics are still associated with walking behavior even after accounting for residents' attitudes and preferences (Handy, Cao, & Mokhtarian, 2006).

Child-level Factors

Age. There is evidence to suggest that a reduction in physical activity may be observed in older children in the 6-11 year age range currently under study (Nader et al, 2008). There is also evidence that where children are active may differ by their age. In a longitudinal study, Wall et al examined age trajectories of children's activity in organized setting vs. free time settings over a five-year span and found that physical activity declined with age in both types of settings, but that they declined at different ages for girls (between 10-11 years of age for free time) and boys

(between 14-15 years of age for free time) (Wall, Carlson, Stein, Lee, & Fulton, 2011). In addition, Veitch and colleagues found that parents of 6 to 8 year olds viewed their children as less independent relative to parents with 9 to 10 year olds, with the latter parent group more likely to allow their children to walk to a friend's house or play in a park unsupervised (Veitch, et al, 2006).

Child's Sex has been found to be an effect modifier in various built environment characteristics and adolescents' physical activity levels, with boys typically achieving higher levels of physical activity relative to girls (Carver et al, 2010; Gomez et al, 2004; McDonald et al, 2009; Norman et al, 2006; Romero, 2005; Williams & Green, 2001). However, others have found no modifying relationship, particularly in children who are younger (Kerr et al, 2006; Valentine & McKendrick, 1997), although Brown and colleagues did find a difference in amount of sedentary behaviors between 4th grade boys and girls depending on the type of crime, with higher amounts of sedentary time for boys with higher burglary rates and higher amounts of sedentary time for girls with greater presence of sexual offenders (Brown et al, 2008).

Race/Ethnicity is proposed to be associated with both parents' neighborhood perceptions (crime in particular) and children's physical activity levels. In a discussion regarding New Urbanism, Day cited statistics from the Bureau of Justice which stated that more non-White individuals are likely to state that they are fearful of walking in their neighborhoods at night than Whites (2006). This may be because of evidence that non-White individuals may be more likely to be exposed to crime and violence (Hillier, 2008; McDonald et al, 2009; Williams & Green, 2001).

In summary, this dissertation is informed by literature and conceptual models that have been grounded in the fields of health services research, public health, urban planning, and criminology. These models guide the conceptualization and implementation of this dissertation research.

Chapter 2: The Effect of Children's Weight Status and Physical Activity on Health Care Visits and School Absences: Findings from an Observational Prospective Cohort Study

Introduction

There are several far-reaching benefits for regular physical activity in childhood. In a large systematic review, the 2008 Physical Activity Guidelines Advisory Committee concluded that for youth and adolescents, increased physical activity was associated with increased cardiorespiratory fitness and muscular strength, enhanced bone health, reduced symptoms of depression and anxiety, a reduction in risk factors for cardiovascular and metabolic diseases, and reduced body fatness (Physical Activity Guidelines Advisory Committee, 2008). Strong and colleagues also found robust evidence for physical activity's beneficial health effects for musculoskeletal health, lower blood pressure in mildly hypertensive youth, and lower cardiovascular risk factors and adiposity in overweight youth. They also found adequate evidence for physical activity's additional health benefits in lipid levels, self-concept, anxiety, depression symptoms, academic performance, and adiposity in healthy-weight youth (Strong, et al, 2005). Boreham and Riddoch argued that regular physical activity in childhood not only has immediate health benefits, but that benefits extend into adulthood in two ways: by staving off the onset of chronic health conditions such as cardiovascular disease through reducing risk factors in childhood, and increasing the likelihood of consistent physical activity as children age by maintaining their current physical activity levels into their adulthood (Boreham & Riddoch, 2001).

The role of regular physical activity in childhood is particularly critical as more children are classified as overweight or obese than before and trends continue to rise (Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007; Troiano, et al, 2008). Children are considered overweight

if their BMI falls between the 85th percentile and less than 95th percentile, and obese if their BMI is greater than or equal to 95th percentile for their age and sex (CDC, 2011). Using 2007-2008 data, Ogden and colleagues estimated that approximately 35.5% of 6-11 year old US children were at or above the 85th percentile and 19.6% were at or above the 95th percentile (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010). To slow these trends, regular physical activity is being examined as a primary and secondary prevention tool against childhood obesity by preventing children from becoming overweight and reducing or maintaining weight if obesity develops. In a longitudinal study, children's physical activity and body adiposity (measured by skinfold thicknesses and BMI) were measured annually beginning at four years old until they were 11 years old (Moore, et al, 2003). Children were divided into tertiles of activity levels, and children in the highest activity group had the smallest gains in BMI and skinfold thickness by age 11. Furthermore, they found that high levels of physical activity were an even stronger protective factor in weight gain trajectories for girls than boys (although this significant protective effect was evident in both boys and girls in the highest activity group). The authors concluded that establishing regular physical activity as early as 2 or 3 years of age is critical for preventing obesity in later childhood and adolescence (Moore, et al, 2003). Others have also found significant negative associations between physical activity and body adiposity in 9-10 year old European children, but noted that physical activity appeared to play a much smaller role than some demographic factors including sex and birth weight (Ekelund, et al, 2004). Collectively these findings suggest the role of physical activity in preventing or slowing childhood obesity and other health concerns cannot be ignored.

Evidence suggests that children who are overweight or obese use more health care than children who have a healthy BMI percentile for their age and sex. Children in the U.S. are generally a healthy population (Cayce et al, 2005; Neff, Sharp, Muldoon, Graham, & Myers, 2004) with most of their health care use in the form of routine check-ups (Cayce et al, 2005). However, even in this mostly healthy population, higher health care use is associated with acute or chronic conditions (Neff et al, 2004), severity of condition (Neff et al, 2004), and overweight and obesity (Estabrooks & Shetterly, 2007; Hampl, Carroll, Simon, & Sharma, 2007; John, Wenig, & Wolfenstetter, 2010). Estabrooks and Shetterly estimated that children who were obese had 6-11% higher rates of clinic visits relative to children with a healthy weight in an integrated health care system setting, but they found no significant differences in rates between overweight and healthy weight children (Estabrooks & Shetterly, 2007). Hampl and colleagues did not find a significant difference between children's visits based on their weight status, but they did find that both overweight and obese children had significantly higher odds of utilizing laboratory services for blood tests relative to healthy weight children (Hampl, et al, 2007). These increased uses of services in children who are overweight and obese were also associated with higher costs (Estabrooks & Shetterly, 2007; Hampl, et al, 2007; John, et al, 2010). As high health care costs and utilization continue to be a focus of the health care and political arenas, it is important to determine whether relationships exist between healthy behaviors (i.e. regular physical activity) and health outcomes (i.e. obesity and other chronic conditions) and health care utilization.

It is unclear whether children's physical activity is related to their health care utilization and whether this association is mediated by child weight status. Higher levels of physical activity

lower the odds of health care use among asthmatic adults (Dogra, Baker, & Ardern, 2009). In addition, Dogra and colleagues found that adults with asthma who were obese and inactive had significantly higher odds of health care use and inpatient hospitalizations relative to adults with asthma who were obese but active (Dogra, et al, 2009). This suggests that physical activity may attenuate the odds of increased health care use in adults with asthma even after accounting for overweight or obese weight status. In another study by Woolcott et al, inactivity was associated with a significant increase in hospitalizations and health care visits in a survey sample of Canadian older adults (Woolcott, Ashe, Miller, Shi, & Marra, 2009). However, less is known about whether these associations found in adult populations extend to children. If a relationship such as this is found between children's physical activity, weight status, and health care use, then an even stronger case can be made for the importance of preventive health behaviors, specifically physical activity. Not only would it strengthen the case for health benefits resulting from physical activity in childhood, but it would also present new evidence of the role of childhood health behaviors in reducing health care use and associated costs.

Another health and social outcome related to children's health and weight is school absences. Evidence suggests children with chronic conditions miss more school days relative to their healthy counterparts (McDougall et al, 2004). In addition, others have found that elementary school children who are obese miss more school days than children who have a healthy weight, even after accounting for other important demographics including age, sex and race/ethnicity (Geier, et al, 2007). Authors also concluded that there is a negative association between childhood weight status and academic performance, with preliminary evidence supportive of Geier et al's findings (Taras & Potts-Datema, 2005). If physical activity potentially

attenuates the role of higher weight status on increased health care use, it is possible that physical activity may play a similar role in the relationship between children's higher weight status and more school absences. Exploring school absences as an outcome is important not only for child consequences, but also because costs of children staying at home trickles into other realms like a parent taking time off of work to care for a sick child (Diette, et al, 2000; Palmer, Rousculp, Johnston, Mahadevia, & Nichol, 2010).

This study's primary aim was to examine the relationship between 6-11 year old children's baseline weight status and physical activity levels and their subsequent annual health care use that occurred approximately one year later assessed retrospectively at 2-year follow-up. Physical activity was proposed to play a moderating role in children's health care use by attenuating the positive association previously found between weight status and health care use in youth. Since most of children's health care is typically routine check-ups, a sensitivity analysis also examined these associations for illness-related only health care visits. Because evidence suggests that overweight or obese weight status can increase the risk of other health conditions like high blood pressure or lipid levels, it was possible that the role of a child's weight status on health care use was mediated by additional health conditions. Thus, the role of weight on children's health care visits was examined with and without the presence of other health conditions (Estabrooks & Shetterly, 2007).

To further explore the roles of weight and physical activity on children's health, the second aim examined the relationship baseline weight status and physical activity and number of school days missed because of illness in an academic year assessed retrospectively at 2-year follow-up.

Methods

Study Design

The study used baseline and 2-year follow-up data from an observational prospective cohort study, the Neighborhood Impact on Kids (NIK) Study, which examined neighborhood and individual factors related to weight and behaviors associated with weight (i.e. physical activity and nutrition behaviors). Participants were children aged 6 to 11 years in King County-Seattle, WA and San Diego County, CA. Children were selected from neighborhoods based on their neighborhood physical activity and nutrition environments (described in Chapter 3).

This study was approved by the Institutional Review Boards at Seattle Children's Hospital and San Diego State University.

Participants & Recruitment

Details of the recruitment and study procedures are described elsewhere (Saelens, et al, unpublished). Briefly, between September 2007 and January 2009, participants were randomly selected and recruited from households within the selected neighborhoods of the two counties. To be eligible, children had to be between the ages of 6 and 11 years old and have a parent or legal guardian also willing to participate. In addition, children had to be able to engage in moderate-to-vigorous physical activity and meet additional inclusion and exclusion criteria related to growth and weight (Saelens, et al, unpublished). Participants were re-contacted between September 2009 and March 2011 to complete follow-up assessments two years after their baseline.

Baseline data were collected from 730 participants. Beginning in June 2010, a supplemental parent questionnaire asking about their child's health and health care utilization

was added to participants' follow-up assessments after follow-up data collection had already started. Because of issues of feasibility and potential participant burden, participants who had already completed their follow-up assessments prior to June 2010, were not re-contacted and asked to complete the questionnaire. All parents who were asked to complete this additional questionnaire agreed. Only participants who completed the health care questionnaire at two-year follow-up and had complete data for all covariates were included in the current analyses, resulting in a final sample of 260 children.

Measures

Child's baseline weight status

Children's height and weight were assessed at baseline using a stadiometer and digital scale, respectively. Height was measured to the nearest 0.1 cm and weight to the nearest 0.1 kg. Both measurements were taken three or more times and averaged across number of measurements; if three height measurements were not within 0.5 cm or weight within 0.1 kg, then additional measure were taken until three of four consecutive measurements met the respective criterion. BMI percentile specific to child's age and sex was calculated using CDC growth charts, and classified as healthy weight if BMI percentile was between 5th and less than 85th percentile, overweight or obese if at or above the 85th percentile (Kuczmarski, et al, 2002).

Physical Activity

Children's baseline physical activity was measured by the MTI (formerly CSA) GT1M Actigraph accelerometer. The Actigraph has been validated and calibrated for use among children (Freedson, et al, 1997). Accelerometers were initialized to sample and store activity counts beginning at 00:00:01 (i.e. 12:00:01AM) on the first day of expected wearing.

Participants were asked to wear the accelerometer for at least seven valid days, for at least 10 hours per day, during their waking hours. Upon return, the accelerometer was downloaded and screened by hour for completeness and possible irregularities or malfunction. Participants were asked to re-wear the accelerometer if it was not worn for at least 10 valid hours on at least 6 days. For scoring purposes, a valid day was defined as a day that had at least 8 valid hours, and a valid hour was defined as one that had no more than 20 minutes of consecutive zero counts.

Physical activity count data were captured in 30-second epochs. These counts in turn were converted into activity intensity by using pre-established age-specific cut points, with moderate-intensity activity defined as 4+ METs up to vigorous-intensity, defined as 6 METs or greater. Participants' ages were rounded to a half-year and age-based cut points derived from the Freedson equation (Freedson, et al, 1997). Average daily moderate-to-vigorous physical activity (MVPA) time was aggregated to minutes and summed for each 8-hour valid day and divided across number of valid days for children who had at least three valid days.

Although recommendations for adults encourage that moderate-to-vigorous physical activity is accrued in bouts of at least 8-10 minutes (Troiano et al, 2008), these recommendations may not be appropriate for children. Moreover, no current bout length minimums have been established for children (Mâsse et al, 2005). Thus, all 30-second epochs that met the MVPA MET thresholds were included in this measure regardless of amount of time MVPA was sustained. Children were categorized as having met daily MVPA recommendations if their average daily MVPA was greater than or equal to 60 minutes, and not meeting recommendations if less than 60 minutes.

Number of health conditions measured at 2-year follow-up

Parents were asked to report if a doctor had ever told them if their child had any of a number of conditions in their child's lifetime at 2-year follow-up, based on the modified National Health and Nutrition Examination Survey (NHANES) Medical Conditions Questionnaire (CDC, 2009). In addition, the survey incorporated other conditions likely to be found in general childhood but not listed in NHANES (Cayce et al, 2005; Neff et al, 2004). The NIK Study listed the following conditions and three 'other' free response spaces for parents to list any additional conditions: anxiety; asthma; ADHD or ADD; depression; diabetes; high blood pressure; high cholesterol or high triglycerides; and orthopedic conditions related to bones and joints but not including broken bones or other traumatic injuries. 'Other' responses were all reviewed and deemed valid health conditions. Number of conditions including 'other' responses was summed and dichotomized into children having none versus one or more reported health conditions (range: 0 to 4).

Individual & household demographics

Demographic measures collected by parent-reported survey at baseline included child's age, sex, race/ethnicity (categorized into non-Hispanic white, Hispanic, and non-Hispanic non-white), highest education in the household (categorized into completed high school or less, some college, completed college, and completed graduate or professional degree), and household income (categorized into <$50k, $50-100k, and >$100k). Health insurance coverage in the past 12 months was also assessed for children by parent report (categorized into full coverage, intermittent, and no health insurance in the past 12 months) and was fairly pervasive with 95.7% of the children having full coverage. Because of this lack of variability, health insurance status was not included in the models.

Outcomes

Total annual health care visits

At 2-year follow-up, parents were asked to list the type of health care visits their child had in the past 12 months (excluding overnight hospitalizations) and the total number of visits for each type. This question was modified from the NHANES Hospital Utilization and Access to Care Questionnaire (CDC, 2009). The types of visits were: primary care (pediatric) routine check-ups (well child visits); primary care (pediatric) sick visits; sports physicals; mental health visits; emergency department visits; and specialty visits (parents were asked to specify these visits). This list was based primarily on Estabrooks and Shetterly's study (2007), with additional types of visits informed by other studies (Cayce et al, 2005; Hampl et al, 2007). Examples of specialty visits noted by parents included dermatology, neurology, and chiropractic appointments. Some parents listed dental and orthodontic visits under 'specialty visits.' Although child oral health is an important public health issue (e.g., de Silva-Sanigorski, et al, 2011), this type of visit was not explicitly asked. Since these visits may have occurred for other children but not reported, dental visits were excluded in the final outcome. Annual health care visits were therefore the sum of all types of visits excluding dental/orthodontic visits (where reported).

Annual sick visits

Annual sick visits were calculated as total annual health care visits subtracting out number of well child visits and sports physicals (i.e. the sum of primary care (pediatric) sick visits; mental health visits; emergency department visits; and specialty visits).

School absences

At the 2-year follow-up, parents reported the number of days their child was absent from school because of illness in the previous complete school year. If a child was homeschooled, parents were asked to report number of days their child did not receive instruction because of illness.

Data analyses

All analyses were conducted using STATA 11 SE. Descriptive statistics for basic child and household demographics were performed. Pearson product moment correlations were estimated between all health care use and school absence outcomes, weight status, moderate-to-vigorous physical activity (MVPA), and total number of health conditions. To address the first aim of the study, a generalized linear model with Poisson family and log link was conducted in three stages with total health care visits as the outcome. First, MVPA, weight status and an interaction term between these two variables were entered into the model. Second, because having any health conditions may mediate the role of weight status on health care use, analyses were performed with and without any health conditions in the model to address potential issues of mediation (Chmura Kraemer, Kiernan, Essex, & Kupfer, 2008). Third, all other demographic variables (i.e. child age, sex, race/ethnicity, highest household education, and household income) were included in the model last. These same models were also performed with total sick visits as the outcome. To address the second aim, the same generalized linear models with Poisson family and log link were performed with number of school absences as the outcome. All significance levels were set at alpha<0.05.

Results

Table 2.1 presents demographics, weight characteristics, physical activity levels, and health care visits and school absences of the sample. Children were equally divided by sex, primarily non-Hispanic white, and tended to live in households that were well educated and affluent. About a quarter of our children were overweight or obese, and about a third did not meet daily physical activity recommendations. Of the reported health conditions, almost 10% of parents reported that their child had asthma, 6.5% had attention-deficit disorder or attention-deficit hyperactivity disorder (ADD/ADHD), about 4% reported anxiety, over 2% reported an orthopedic condition, over 1% reported depression, almost 1% reported high cholesterol or high triglycerides, and less than 1% reported diabetes. No parents reported that their child had high blood pressure, and about 12% reported other conditions not listed; these other conditions included allergies and autism spectrum disorders, among others. About a third of the children had at least one health condition, and approximately 8% of the children had two or more health conditions.

Table 2.2 presents Pearson's r correlations of health care use, school absences, weight, physical activity, and health conditions. All three outcomes of interest were positively and significantly correlated with one another. Meeting physical activity recommendations and being overweight or obese were not statistically significantly related to any of the health care visit or school absence measures, however. Being overweight or obese was significantly associated with not meeting daily MVPA recommendations. Of the children with a normal/healthy BMI percentile ($<85^{th}$ percentile), approximately 31% did not meet the daily recommendations of at least 60 minutes per day of moderate-to-vigorous physical activity, whereas of the children with an overweight/obese BMI percentile ($\geq 85^{th}$ percentile), almost 58% did not meet the daily

recommendations. Having a higher number of health conditions at 2-year follow-up was significantly associated with several other variables including higher total health care visits and sick visits, not meeting daily MVPA recommendations, and being overweight or obese. About 34% of children with no reported health conditions did not meet daily physical activity recommendations, whereas almost 46% of children with one or more health conditions did not meet the recommendations. An exploratory two sample t-test revealed that children with a healthy baseline weight status were less likely to have 1 or more health conditions at 2-year follow-up (26.3%) than children with an overweight or obese weight status (53%) (p=0.0001).

Total annual health care visits

Table 2.3 presents incidence rate ratios for total health care visits. Children's weight status had no statistically significant association with health care visits and did not change with or without any health conditions in the model. Physical activity and its interaction with children's weight status were also not statistically significant in the model. Having any health condition yielded a 90% increase in total health care visit rates relative to children who had no health conditions. Children living in a household where the highest education was higher than college graduation had a 41% reduction in total health care visit rates relative to children living in a household where the highest education obtained was some college or less. Children living in a household that had an income greater than or equal to $50,000 had higher total health care visit rates of over 70% relative to those living in a household with an annual income below $50,000.

Annual sick visits

Incidence rate ratios of sick visits are presented in Table 2.4. Children's weight status and physical activity were not statistically significantly related to number of annual sick visits,

regardless of whether or not having any health condition was included in the model. Having any health condition was related to higher sick visit rates, over two times greater than children who had no health conditions. Those who identified as non-Hispanic non-white had 52% lower sick visit rates relative to those who identified as non-Hispanic white. Children living in a household where the highest education was more than college graduation had a 55% reduction in sick visit rates relative to children living in a household where the highest education obtained was some college or less. Children living in a household that had an income greater than or equal to $50,000 had almost 300% higher sick visit rates relative to those living in a household with an annual income below $50,000.

School absences

Table 2.5 presents incidence rate ratios for school absences. Again, children's weight status, physical activity, and their interaction were not statistically significant in the models with and without any health conditions included. Those who identified as Hispanic had a 50% lower school absence rate relative to those who identified as non-Hispanic white.

Discussion

The primary findings of our study are that physical inactivity and overweight/obese status are positively associated with number of child health conditions, but not related to greater health care use or school absence after accounting for number of health conditions. Although physical activity is an important health promoting behavior for children's weight status and other health conditions, it may be that benefits of physical activity in the form of reduced health care use do not manifest until several decades later and were therefore not captured in our 2-year timeframe (Must & Strauss, 1999). As opposed to directly affecting children's health care use, physical

activity in childhood may instead indirectly affect adult health and health care use by establishing health promoting habits that carry into adulthood (Boreham & Riddoch, 2001). It may also be that physical activity plays a smaller role in children's weight status, just as Ekelund et al reported that physical activity accounted for less than 1% of the variance in children's adiposity after accounting for other factors (Ekelund, et al, 2004), but others have also found a stronger predictive relationship than this, too (Moore, et al, 2003). It could be that a relationship between physical activity and weight status in children is overshadowed by other more immediate factors that may impact health care use like having any health conditions, which our findings support.

Our finding that weight status did not significantly predict health care use or school absences does not provide additional evidence beyond past studies that have found significant relationships (Estabrooks & Shetterly, 2007; Geier, et al, 2007; Hampl, et al, 2007). The previous health care studies used much larger samples than ours and found only small but significant increased odds of health care utilization in overweight and obese children relative to children with a healthy weight (Estabrooks & Shetterly, 2007; Hampl, et al, 2007). In addition, Geier and colleagues findings of higher school absences for obese children also used a larger sample that was predominantly comprised of black, Asian, and Hispanic children, with more than 80% receiving free or reduced lunch (Geier, et al, 2007). Our study therefore may not have had sufficient power to detect this small but significant impact of weight status on health care utilization and school absences. Moreover, our sample was predominantly non-Hispanic white and more affluent relative to previous study samples, and our follow-up may have been too short to capture these effects, particularly for health care use outcomes.

Although weight status in the present study was not significantly associated with health care use, there was evidence that overweight/obesity was significantly related to having at least one health condition. Childhood health consequences related to overweight/obesity span the entire bodily system from orthopedic conditions to neurological, gastroenterological, endocrine, and pulmonary issues like asthma and sleep apnea (Must & Strauss, 1999). In addition, children who are obese are more likely to have cardiovascular risk factors that can lead to chronic illness in both their youth and adulthood (Freedman, et al, 2007; Thompson, et al, 2007). Children who have one or more health conditions have significantly higher rates of health care visits relative to children with no reported health conditions. This finding supports previous work that children with chronic conditions tend to use health services more than their healthier counterparts (Kogan, et al, 2010; Neff, et al, 2004). Collectively, these findings indicate that having a healthy weight may reduce the risk for chronic conditions, which in turn may be associated with reduced health care utilization rates.

The other consistent finding in our study is that children living in households that fell in higher income categories that were greater than or equal to $50,000 also have higher rates of health care visits relative to children living in households with incomes below $50,000. These higher rates of health care use for children in higher income households have two possible interpretations for consideration. First, it could mean these children have a greater need for care. Second, perhaps need is not the issue but instead these results are indicative of increased access to care for children in higher income households. We asked parents about their child's health insurance coverage during the past 12 months and whether or not they had continuous coverage, intermittent coverage, or no health insurance. Health insurance coverage was fairly ubiquitous in

the current study with almost all parents reporting continuous coverage over the past 12 months for their child. Of the few participants with intermittent or no health insurance during that timeframe, they were fairly equally distributed across the three income categories with no significant differences by income.

Many have argued that health insurance coverage for children is necessary but not sufficient for addressing and reducing disparities for children's health outcomes and access to care by income, race/ethnicity, and other social determinants of health (Currie, 2009; Feinberg, Swartz, Zaslavsky, Gardner, & Klein Walker, 2002; Kogan, et al, 2010; Rosenbach, Irvin, & Coulan, 1999; Vivier, 2005). The primary issue that appears to resonate for families who have insurance but still do not have adequate access to care is additional out of pocket costs (Currie, 2009; Feinberg, et al, 2002; Kogan, et al, 2010; Owen, 2009). As health care costs continue to rise, private health insurance policies like health savings accounts (HSAs) shift more of the costs to the families, which may in fact further hinder access to care for families with lower household incomes enrolled in health insurance with these options (Owen, 2009). Thus, regardless of type of health insurance coverage, it is possible that our findings of lower health care use rates for our lower income participants may be tapping into issues of health care access and unmet need. Since we did not specifically ask for further details of health insurance coverage, though, these conclusions are speculative.

This study's addition to the literature includes examining children's physical activity as it relates to their weight status and prospective health care use and school absences. To our knowledge, this has not been studied before and is a strength of the study. An additional strength of this study is the use of objective measures for children's weight status and physical activity.

Although the current study did not find strong relationships between our exposures and outcomes of interest, future studies with larger samples and longer follow-up that examine children's weight and physical activity in relation to their health outcomes and use may find significant results. Tracking health care use and school absences prospectively vs. retrospective recall at follow-up potentially could strengthen subsequent studies. Another approach would be to measure all of our exposures and outcomes of interest at both baseline and follow-up; this may provide additional insight into changes in children's physical activity, weight, health conditions, health care use, and school absences over time. In fact, measuring all of our primary variables of interest at childhood baseline and prospectively tracking them into adulthood not only could demonstrate nuanced relationships between these measures but would provide a life-course perspective. A life-course perspective champions health and wellbeing in childhood, because it is recognized that a healthy childhood can improve population health by preventing precursors of adult health conditions (Forrest & Riley, 2004).

Even though the predictors precede the outcome (and thus begin to strengthen an argument for direction of any significant findings), one limitation of this study is that causality cannot be established based on its study design. For example, additional unmeasured confounding may be present in the relationship between having any health conditions and annual health care visits; perhaps children with a diagnosed condition are more likely to have a usual source of care and see their primary care provider more often for check-ups related to their condition relative to children without a diagnosis. In addition, our study was unable to replicate past findings of an association between children's weight status and health care use and school absences. This may be a result of insufficient power to detect a statistically significant difference

based on the current sample size. Our study also used parent-reported measures to determine health care use and school absences, which comes with drawbacks such as memory and recall bias. As an aside, but still important to note, future studies that also examine dental health and health care use may find additionally relevant findings, particularly since there is evidence of variation by income (de Silva-Sanigorski, 2011).

Although a relatively healthy population, children's health care use is still an important issue in the current political climate of high health care costs. If there are preventable actions that can be implemented now to prevent current and future health conditions as children age, there is potential to reduce health care use and costs from this population. Not only have some chronic conditions in youth been linked to obesity, but they have the potential to be lessened in severity with weight loss or management (e.g., TODAY Study Group, 2010). Using a life-course perspective, future research and policy that explores health promoting behaviors like physical activity in childhood could provide new insight into youth and adult health and health care outcomes.

Acknowledgments

The NIK project was supported by the NIH National Institute of Environmental Health Sciences (NIEHS R01 ES014240), Grant #UL1RR025014 from the National Center for Research Resources (NCRR), a component of the National Institutes of Health (NIH), and the Nutrition Obesity Research Center at the University of Washington (NIH Grant #P30DK035816).

The authors would like to thank all of the NIK children and parents for their participation.

Table 2.1. Demographic Characteristics of Study Sample		
Mean age at baseline, years, (SD)		9.1
Sex, n, (%)	Male	130
	Female	130
Race/Ethnicity, n, (%)	Non-Hispanic white	195
	Hispanic	28
	Non-Hispanic non-white	37
Household education[a], n, (%)	Some college or less	42
	College graduate	111
	More than college graduate	107
Household income[a], n, (%)	<$50k	29
	$50-100k	88
	>$100k	143
Mean BMI percentile at baseline, (SD)		62.7 (25.7)
Baseline weight status, n, (%)	Healthy BMI percentile (5th - <85th percentile)	194 (74.6)
	Overweight/Obese BMI percentile (≥85th percentile)	66 (25.4)
4MET Avg Daily MVPA at baseline, min		76.0 (34.1)
Met MVPA 4MET recommendation at baseline, n, (%)	Met recommendations	161 (61.9)
	Did not meet recommendations	86 (33.1)
Any health conditions at 2-year follow-up, n, (%)	No reported health conditions	174 (66.9)
	At least one health condition	86 (33.1)
Total health care visits in past 12 months at 2-year follow-up, (SD)		2.5 (2.6)
Total sick health care visits in past 12 months at 2-year follow-up, (SD)		1.6 (2.4)
School absences because of illness over past school year at 2-year follow-up, (SD)		2.7 (2.9)

Table 2.1. Demographic Characteristics of Study Sample, continued
Abbreviations: SD, standard deviation; MVPA, moderate-to-vigorous physical activity. [a]=Percentage totals not equal to 100% because of rounding

Table 2.2. Bivariate Correlations, Pearson's r (p-value)

	Total health care visits	Total sick visits	School absences	Total # health conditions	Overweight or obese	Met 4MET MVPA recommendations
Total health care visits	1.00					
Total sick visits	0.95 (<**0.0001**)	1.00				
School absences	0.27 (<**0.0001**)	0.28 (<**0.0001**)	1.00			
Total # health conditions	0.36 (<**0.0001**)	0.33 (<**0.0001**)	0.05 (0.38)	1.00		
Overweight or obese	-0.01 (0.90)	-0.001 (0.98)	-0.003 (0.96)	0.23 (**0.0001**)	1.00	
Met 4MET MVPA recommendations	0.01 (0.92)	0.01 (0.92)	0.01 (0.89)	-0.15 (**0.02**)	-0.24 (**0.001**)	1.00

Table 2.3. Total Health Care Visits' Incidence Rate Ratios, Fully Adjusted

		IRR (95% CI)	p-value
Overweight/obese[a]		0.83 (0.59, 1.16)	0.28
Met MVPA daily recommendations[b]		1.00 (0.76, 1.31)	0.97
Weight * MVPA interaction		1.16 (0.74, 1.84)	0.51
Any health conditions[c]		1.90 (1.51, 2.39)	**<0.001**
Age		1.00 (0.93, 1.09)	0.91
Female[d]		0.97 (0.76, 1.23)	0.79
Race/Ethnicity[e]	Hispanic	0.92 (0.69, 1.23)	0.58
	Non-Hispanic non-white	0.74 (0.54, 1.03)	0.08
Household education[f]	College graduate	0.70 (0.48, 1.01)	0.06
	More than college graduate	0.59 (0.41, 0.84)	**0.004**
Household income[g]	$50-100k	1.73 (1.21, 2.48)	**0.003**
	>$100k	1.72 (1.20, 2.46)	**0.003**

Abbreviations: IRR, incidence rate ratio; CI, confidence interval; MVPA, moderate-to-vigorous physical activity

[a]referent category=healthy BMI percentile; [b]referent category=did not meet daily MVPA recommendations; [c]referent category=no reported health conditions; [d]referent category=male; [e]referent category=non-Hispanic white; [f]referent category=some college or less; [g]referent category=<$50k HH income

Table 2.4. Total Sick Visits' Incidence Rate Ratios, Fully Adjusted

		IRR (95% CI)	p-value
Overweight/obese[a]		0.80 (0.50, 1.30)	0.38
Met MVPA daily recommendations[b]		0.99 (0.67, 1.47)	0.97
Weight * MVPA interaction		1.22 (0.66, 2.28)	0.52
Any health conditions[c]		2.33 (1.65, 3.27)	**<0.001**
Age		0.99 (0.88, 1.10)	0.80
Female[d]		1.00 (0.70, 1.43)	1.00
Race/Ethnicity[e]	Hispanic	0.94 (0.57, 1.55)	0.80
	Non-Hispanic non-white	0.48 (0.28, 0.83)	**0.008**
Household education[f]	College graduate	0.62 (0.37, 1.05)	0.07
	More than college graduate	0.45 (0.28, 0.74)	**0.002**
Household income[g]	$50-100k	2.98 (1.64, 5.42)	**<0.001**
	>$100k	2.87 (1.54, 5.34)	**0.001**

Abbreviations: IRR, incidence rate ratio; CI, confidence interval; MVPA, moderate-to-vigorous physical activity

[a]referent category=healthy BMI percentile; [b]referent category=did not meet daily MVPA recommendations; [c]referent category=no reported health conditions; [d]referent category=male; [e]referent category=non-Hispanic white; [f]referent category=some college or less; [g]referent category=<$50k HH income

Table 2.5. School Absences' Incidence Rate Ratios, Fully Adjusted

		IRR (95% CI)	p-value
Overweight/obese[a]		0.87 (0.55, 1.39)	0.57
Met MVPA daily recommendations[b]		0.96 (0.65, 1.42)	0.85
Weight * MVPA interaction		1.25 (0.64, 2.45)	0.52
Any health conditions[c]		1.18 (0.88, 1.56)	0.27
Age		0.98 (0.88, 1.09)	0.71
Female[d]		0.97 (0.73, 1.28)	0.81
Race/Ethnicity[e]	Hispanic	0.50 (0.28, 0.88)	**0.02**
	Non-Hispanic non-white	0.76 (0.54, 1.08)	0.13
Household education[f]	College graduate	1.09 (0.71, 1.69)	0.70
	More than college graduate	0.93 (0.59, 1.46)	0.76
Household income[g]	$50-100k	0.90 (0.50, 1.62)	0.72
	>$100k	0.83 (0.48, 1.46)	0.52

Abbreviations: IRR, incidence rate ratio; CI, confidence interval; MVPA, moderate-to-vigorous physical activity

[a]referent category=healthy BMI percentile; [b]referent category=did not meet daily MVPA recommendations; [c]referent category=no reported health conditions; [d]referent category=male; [e]referent category=non-Hispanic white; [f]referent category=some college or less; [g]referent category=<$50k HH income

Chapter 3: Children's Objective Physical Activity by Location: Cross-sectional Findings

Introduction

Regular physical activity for children that meets recommendations of at least 60 minutes per day has been shown to have far reaching health benefits, including reducing risk for chronic disease and obesity (CDC, 2008; Physical Activity Guidelines Advisory Committee, 2008). Additionally, physical activity in informal settings, such as outdoor neighborhood play, has benefits of developing physical and mental creativity (Valentine & McKendrick, 1997). Informal play also tends to provide more physical activity than structured activity like organized sports (Mackett & Paskins, 2008), particularly more sedentary sports. More research is needed examining children's immediate environments and how context may influence their moderate-to-vigorous physical activity (MVPA) (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008). Some have also argued that parents' perceptions of various neighborhood factors may influence children's physical activity (e.g. Weir, Etelson, & Brand, 2006). Knowledge of where children are active and facilitators and barriers to physical activity is important for policy and interventions targeting physical activity (Foster & Giles-Corti, 2008), because it may lead to more informed policies about how and where to intervene.

Past studies examining where children are active typically have relied upon retrospective parent-report of both physical activity and its location. In a sample of 6-11 year olds, Grow and colleagues found that the five most commonly used locations for physical activity (as reported by parents) were swimming pools, small public parks, playgrounds, play fields/courts, and large public parks. In contrast, they reported that the five least commonly used locations by this age group were school recreation facilities, beaches and other outdoor water recreation sites, trails,

basketball courts, and walking/running tracks (Grow et al, 2008). In a younger sample, parents reported the most frequented locations for 5 to 8 year old children's physical activity were their own yard or apartment complex, a park or playground, school grounds during after-school hours, and a friend or relative's home (Corder, Sallis, Crespo, & Elder, 2011). Finally, using a qualitative approach, 74% of Australian parents of school-aged children reported that the primary place that their children engaged in physical activity was in their own yard at home (Veitch, Bagley, Ball, & Salmon, 2006).

There is also evidence that where children are active may differ by their age, sex, race/ethnicity, and household income. In a longitudinal study, Wall et al examined age trajectories of children's activity in organized setting vs. free time settings over a five-year span and found that physical activity declined with age in both types of settings, but that they started to decline at different ages for girls (between 10-11 years of age for free time) and boys (between 14-15 years of age for free time) (Wall, Carlson, Stein, Lee, & Fulton, 2011). Age by sex differences have also been reported in different organized sports and in-home and out-of home settings (Leek, et al, 2011; Mackett, Lucas, Paskins, & Turbin, 2005). Evidence also suggests that the prevalence of physical activity in organized settings was significantly lower for non-white youth and youth with less educated parents across most ages (Wall, et al, 2011). In a study of Australian children ages 6-7 years old researchers used socioeconomic status (SES) geographic regions as a proxy for household income; they found that parents living in high (SES) regions reported that their child played in their backyards and neighborhoods less and more in private recreation facilities relative to those living in middle and low SES regions. Furthermore, children living in middle SES regions spent more time playing in parks and children living in

low SES regions spent more time playing in public recreation facilities relative to their respective counterparts (Ziviani, et al, 2007).

In most prior studies, parents have been asked to retrospectively assess where their children are active using predetermined locations and to recall the frequency of which their children visit and/or is active at these locations. Limitations to this approach include memory and recall issues, social desirability bias, and challenges with aggregation and categorization (e.g. 'how many times did your child frequent a local park in the past week?'). In addition, Grow and Corder's studies focused primarily on locations that are conducive to physical activity without exploring other locations that may be important, such as their own school, or home (Mackett et al, 2005, 2008; Veitch, et al, 2006, 2009). Having a wider variety of location options that detail where children are throughout their day and using an objective measure to capture physical activity in all of these locations could further solidify evidence about where children are active. It is possible that children accrue physical activity in several different settings not immediately thought of as 'active' locations beyond those that are typically conducive to physical activity (e.g. shopping vs. parks). Existing approaches that fail to take into account the amount of time children spend (active & non-active) in various locations also prevent an estimation of the percentage of time spent in a location that is physically active.

Accelerometery has gained popularity, because it objectively measures physical activity, overcoming inherent limitations in the self-reported measures described above. Accelerometers provide a better way to evaluate physical activity in different settings, because accelerometers can capture the duration and intensity of children's activity in real time rather than relying on parent recall of whether or not and how much their child was active in a given location.

However, an important measurement gap is that accelerometers do not provide information about the location of where children accrue their physical activity. Thus, accelerometry must be accompanied by a measure of children's location. One approach to assessing where children are is to complete a place log of where they are throughout the day and their arrival time at each location while wearing an accelerometer. The accelerometry day/time stamps can link to self- or parent-reported place log days and times. This would allow researchers to objectively assess not only how active a child is but also where that child is being active. Mackett and colleagues have used a similar approach in order to examine older children's active travel from place to place and physical activity (Mackett, et al, 2005; Mackett & Paskins, 2008). For younger children, parent-reported place logs are likely warranted for increased accuracy (Veitch, Salmon, & Ball, 2009).

The primary aim of the current study is to determine where children ages 6-11 accrue their physical activity using accelerometer and parent-reported place logs and to examine variations by age and sex, race/ethnicity, and household income. The second aim is to determine if there are demographic factors, parents' perceptions, and/or neighborhood factors that vary among children who accrue any versus no physical activity in their neighborhoods, and also to determine if average daily moderate-to-vigorous physical activity differences exist between these children. Examining and understanding demographic and neighborhood differences of where children are active and whether or not they are active in their neighborhood is important for tailoring the 'who,' 'how,' and 'where' of physical activity policy and interventions.

Methods

Study Design

The study used baseline data from an observational cohort study, the Neighborhood Impact on Kids (NIK) Study, which examined neighborhood and individual factors related to weight and behaviors associated with weight (i.e. physical activity and nutrition behaviors). Participants were children aged 6-11 years in King County-Seattle, WA and San Diego County, CA. Neighborhoods were selected based on their neighborhood physical activity and nutrition environments and children were recruited from these neighborhoods (described below).

This study was approved by the Institutional Review Boards at Seattle Children's Hospital and San Diego State University.

Neighborhood Selection

Details of neighborhood selection are described elsewhere (Saelens, et al, unpublished), but briefly, neighborhood was defined as a census block group. Prior to participant recruitment, neighborhoods were evaluated based on several built (e.g., availability of higher quality parks) and nutrition (e.g., presence of a grocery store or supermarket) environment characteristics in King County, WA, and San Diego County, CA using existing (e.g., parcel data on land use to create a land use mix measure) and study-created (e.g., park amenities and quality) information brought into a Geographic Information Systems (GIS). Neighborhoods were divided into one of four neighborhood types whose environments were either deemed supportive or unsupportive of physical activity and/or nutrition: high physical activity environment (PAE)/high nutrition environment (NE); high PAE/low NE; low PAE/high NE; and low PAE/low NE.

Participants & Recruitment

Details of the recruitment and study procedures are described elsewhere (Saelens, et al, unpublished). Briefly, between September 2007 and January 2009, potential participants in the

selected neighborhoods were identified through commercial marketing lists and were randomly selected and recruited. To be eligible, children had to be between the ages of 6 and 11 years old and have a parent or legal guardian also willing to participate. In addition, children had to be able to engage in moderate-to-vigorous physical activity and meet additional inclusion and exclusion criteria related to normal growth (Saelens, et al, unpublished).

Baseline data were collected from 730 participants. Of those 730 participants, 701 had any accelerometer data (regardless of whether or not it met the valid wear criteria). Only participants who had both accelerometer and corresponding place log data (see below) were included in the present study, resulting in a final sample of 682 children.

Place Categorization

Parents were instructed to complete a daily log of where their child went every day their child wore the accelerometer. For each location, they were asked to list the name, address, and any other additional information that would be helpful in determining where the child was. Parents also provided the time that their child arrived at each location and the time the child awoke and went to bed each day. Because of this method of reporting only arrival times, travel time between places was thus attributed to the place from which children left.

Place categories were created to group similar places. Categories were informed by past studies (Handy, Cao, & Mokhtarian, 2006; O'Campo, Salmon, & Burke, 2009) and food enumeration categories previously identified using Nutrition Environment Measurement Surveys (NEMS) (Glanz, Saelens, Sallis, & Frank, 2007; Saelens, Glanz, Sallis, & Frank, 2007). Categories were reviewed by the study team and revised, resulting in a total of 17 place categories. For the purpose of the current study, 7 of these categories were aggregated into 2

resulting in 12 final categories: Home; School; Neighborhood; Others' Homes; Other Schools; Public, Outdoor Parks & Recreation Facilities; Public, Indoor Recreation Facilities; Private Recreation Facilities; Service Locations; Nondescript Geographic Locations; Shopping; and Food Eateries. A description of the 17 original categories and 12 final categories are listed in the Appendix. The first author categorized all places.

To assess for inter-rater reliability of place categorization, 150 days from unique participants were randomly selected. From these participants' data, another study team member separately categorized a total of n=649 places. There was 97.2% rater agreement and kappa=0.96 ($p<0.0001$) with the original categorization. In a sensitivity analysis, places that were identified as 'home' were excluded because this location was seen most frequently and easiest to code, resulting in 299 non-home places. This subset had 94.7% rater agreement and kappa=0.94 ($p<0.0001$).

Locations children visited while wearing the accelerometer were categorized using several methods. First, the two categories 'home' (including their front/back yards) and 'school' had one single location for each participant (i.e. each child had only one address designated as home and one address designated as his or her school). Parents were asked to list 'neighborhood' and provide *no* address when their child was in the area around their home or neighborhood but not in a specific place. Place log entries that met these criteria were categorized without need for additional verification approaches.

All other place categories were composites of several types of locations. Three primary approaches were employed for categorizing locations that fell into the remaining categories. First, several location names were easily categorized using the place category descriptions

described in the Appendix (e.g. "doctor's appointment" categorized as a service location and "Boys & Girls Club" as an indoor public recreation facility). Second, for food locations that fell under the NEMS categories, locations were categorized appropriately to match. Third, for locations that were ambiguous or not immediately identifiable, Google® and Google Maps® were used to identify location categories by entering the parent-provided location name and address. For example, if a parent listed the location "Michael's," it is not immediately clear if this is a location of someone's home or an arts & crafts shopping location. To clarify this, the exact address was entered into Google Maps® to determine if a residential home was located there or a commercial store. Using these methods, all locations for each participant were categorized.

Linking accelerometer data with location

To link children's accelerometer data to the time and places parents reported in the place log, MeterPlus v. 4.2 (www.santechhealth.com) was employed to 'cut' the accelerometer data to match the parent-reported arrival time of each place. Non-overlapping times were entered for each location listed in the place log using the time filter option in MeterPlus. For example, if on a given day a parent reported that her or his child woke up at home at 7:00AM, arrived at school at 9:00AM, came home at 3:15PM, and went to bed at home at 8:45PM, then three separate time filters were created from 7:00AM to 8:59AM, 9:00AM to 3:14PM, and 3:15PM to 8:45PM and linked to the place categories of home, school, home respectively. From this, non-wear, sedentary, light, moderate, and vigorous accelerometer wear times were aggregated within the given timeframe of each place and then up to each place category.

Measures

Physical Activity

Children's physical activity was measured by the MTI (formerly CSA) GT1M Actigraph accelerometer. The Actigraph has been validated and calibrated for use among children (Freedson, et al, 1997). Accelerometers were initialized to sample and store activity counts beginning at 00:00:01 (i.e. 12:00:01AM) on the first day of expected wearing. Participants were asked to wear the accelerometer for seven days, for at least 10 hours per day, during their waking hours. Upon return, the accelerometer was downloaded and screened by hour for completeness and possible irregularities or malfunction. Participants were asked to re-wear the accelerometer if it was not worn for at least 10 valid hours on at least 6 days. A valid hour was defined as one that had no more than 20 minutes of consecutive zero counts.

Physical activity count data were captured in 30-second epochs. Non-wear time was defined as >20 minutes of consecutive zero counts. For wear time, counts were converted into activity intensity by using established age-specific cut points, with sedentary activity as counts ≤100, light-intensity activity as > 100 counts up to age-specific moderate counts, and moderate-intensity activity defined as 3+ METs up to vigorous-intensity, defined as 6+ METs (Freedson, et al, 1997).

Total time at each location was equal to the sum of all sedentary, light, moderate, and vigorous wear time and aggregated to minutes. Non-wear time was excluded from both the numerator and denominator of physical activity measures. Moderate-to-vigorous physical activity (MVPA) time was also aggregated to minutes and summed for each location. Although recommendations for adults encourage that MVPA is accrued in bouts of at least 8-10 minutes (Troiano et al, 2008), these recommendations may not be appropriate for children. Moreover, no

current bout cut points have been established for children (Mâsse et al, 2005). Thus, all 30-second epochs that met the MVPA MET thresholds were included in this measure regardless of amount of time MVPA was sustained.

Average daily MVPA was calculated by summing only MVPA that accrued on days that had at least 8 hours of wear time and dividing by the total number of days that met that criterion. For this measure only, participants with at least 3 valid days of 10+ hours were included (n=667). Children were classified as a 'neighborhood child' if they accrued *any* MVPA in the neighborhood.

Individual-level covariates

Demographic variables assessed by parent-reported survey included child's age, sex, race/ethnicity (categorized into non-Hispanic white, Hispanic, and non-Hispanic non-white), highest education in the household (7 categories with less than 7th grade to completed graduate school), and household income (categorized into <$50k, $50-100k, and >$100k).

Prior Crime Victimization

A dichotomized variable was created from 2 survey questions asking if parents had ever been a victim of crime in their neighborhood and if they knew someone who had been a victim of crime in their neighborhood with responses on a four-point Likert scale ranging from 'strongly disagree' to 'strongly agree.' Prior victimization was present if parents responded with 'somewhat agree' or 'strongly agree' to either or both questions. This variable was created in-line with previous work by Foster and colleagues (Foster, Giles-Corti, & Knuiman, 2010).

Collective efficacy

Previously created and used by Sampson and colleagues, a single summary collective efficacy variable comprised of two scales, social cohesion and informal social control, was created (Sampson, Raudenbush, & Earls, 1997). Items were reverse coded where necessary, and the summary score was the average of parent survey questions such as "people in my neighborhood can be trusted" and how likely would neighbors respond if "they witness a crime in progress" This measure of collective efficacy has been found to have acceptable to good internal reliability (Franzini, et al, 2010).

Self-selection of neighborhood

Three items from the parent survey to represent self-selection of a walkable neighborhood were averaged to create a single variable of importance for selecting their current neighborhood: closeness to shops and services, ease of walking, and closeness to recreation facilities. (Sallis et al, 2009).

Parents' perceptions of neighborhood

Averaged summary variables from the Neighborhood Environment Walkability Scale for Youth (NEWS-Y) previously used and found to be reliable were used to assess parent perceptions of the built and social environment of their neighborhood that may be associated with children's physical activity (Rosenberg, et al, 2009). The perceptions included: neighborhood aesthetics, traffic safety, land use mix access, street connectivity, and bike & pedestrian infrastructure (Rosenberg, et al, 2009). In addition, recreation facility availability and land use mix diversity were assessed by totaling the number of recreation facilities and neighborhood destinations (respectively) within a 10-minute walk of the family's home. These

parent perception variables have been used previously (Grow et al, 2008; Rosenberg, et al, 2009).

Additionally, parents' perceptions of neighborhood crime were measured by using nine questions. A factor analysis was performed with an oblique rotation (assuming that any factors that loaded were correlated with one another), resulting in two factors with eigenvalues greater than 1.0. These factors were titled *stranger danger* and *general crime and disorder*. Complete results have been cited elsewhere, but *stranger danger* was found to have good internal consistency (alpha=0.84) and *general crime and disorder* to have acceptable internal consistency (alpha=0.77) (Kneeshaw-Price, et al, unpublished). Ratings for each set of questions that fell into each factor were averaged to create summary variables, with higher scores indicating a higher concern of that crime factor in the neighborhood.

Neighborhood-level covariates

Neighborhood physical activity environment

Neighborhoods in which participant lived were dichotomized into high physical activity environment or low physical activity environment by combining the neighborhood quadrants (foregoing level of nutrition environment) previously defined to select neighborhoods.

Neighborhood socioeconomic status

Median household income at the census block group (defining neighborhood in this study) was used to measure neighborhood socioeconomic status from the 2000 US Census.

Data Analyses

All analyses were conducted using STATA 11 SE. Descriptive statistics for basic child and household demographics were performed. To address the primary aim, additional descriptive

statistics were estimated to assess the percentage of total time accrued at each place category by dividing the total minutes a child spent at each location by the total minutes they wore the accelerometer. Percentage of time engaged in MVPA at each location was also calculated by dividing MVPA minutes at each location by total minutes at each location. Average daily estimates of MVPA at each location were also assessed by dividing MVPA minutes at each location by number of days the accelerometer was worn.

Physical activity by location was also performed with stratification by age-sex (age divided into 6-8 years old vs. 9-11 years old), race/ethnicity, and household income. Separate analyses of variance (ANOVA) were executed with post-hoc testing to examine any differences among the four age-sex groups, three race/ethnicity categories, and three household income categories. With 12 different tests (one for each location) for these comparisons, Bonferroni corrections were employed to account for the multiple comparisons with alpha=0.05 divided by the number of tests (i.e. 12) to yield a significance criterion of $p<0.004$ for these differences. Bonferroni correction is considered one of the more stringent methods for post-hoc comparisons (Norman & Streiner, 2000), but with the number of tests described here we determined this method to be the most prudent for the present study. Analyses for race/ethnicity and household income were not statistically significant with $p>0.004$ for all of the physical activity by location statistics and not reported.

To address the secondary aim, a multilevel logistic regression with random intercepts with two levels (i.e. child, and census block group as the clustering variable) was conducted to assess for any demographic, neighborhood, or parent perception differences between children who accrued any neighborhood MVPA relative to children who accrued no neighborhood

MVPA. To assess if any neighborhood MVPA was associated with average daily MVPA, a multilevel linear random effects model with two levels (i.e. child, and census block group as the clustering variable) was performed. This analysis was performed twice, once with all average daily MVPA as the outcome, and the other as average daily MVPA with neighborhood MVPA subtracted out as the outcome to see if neighborhood children significantly differed from non-neighborhood children even if their neighborhood MVPA was removed. There were 568 unique census block groups in the current sample, with an average of 1.2 and range of 1-5 children living within each block group. County (i.e. King and San Diego) was originally included in these models but did not significantly differ, and analyses provided herein are from all participants. Significance levels within these multivariate models were set at alpha<0.05.

Results

Table 3.1 presents demographics and average daily moderate-to-vigorous physical activity (MVPA) of the study sample. Children had on average 144 minutes of MVPA each day. Using the 3+ METs criterion, 97.3% of the sample with at least 3 valid days of 10 hours or more (n=667) met daily recommendations of at least 60 minutes of MVPA at 3+METs. Easing the valid day criteria and including all days for the full sample of 682 children, 96.5% of the entire sample met recommendations.

Descriptive statistics of time spent at each location and MVPA by location are provided in Table 3.2. Overall, 19.4% (s.d.=7.0) of children's total awake time was spent engaged in MVPA. Children spent the majority of their time in their own home, with almost half of their total awake time there. Of the total time at home only about 18% was spent engaged in MVPA. The second largest amount of time spent anywhere was at their own school, with 29% of their

total awake time spent there; children on average also spent about 18% of their total school time engaged in MVPA. Interestingly, although children spent on average just under 1% of their time outside in their neighborhood, over 42% of their total neighborhood time was engaged in MVPA. This was the highest percentage of time spent being active in any location, even when compared to locations that are primarily oriented toward physical activity, including private and public recreation facilities (~30-32% of time being active). Indeed, neighborhood time was most similarly active to time spent in public outdoor parks and recreation locations (~40% of time being active).

Of all the MVPA children accrued, 43.9% (s.d.=17.5) or about 63 minutes was accrued at home, followed by 27.6% (s.d.=17.8) or almost 38 minutes at school, and 7.2% (s.d.=8.8) or roughly 10 minutes at others' homes. For locations conducive to MVPA such as public, outdoor parks and recreation facilities and the neighborhood, 4.8% (s.d.=7.3) and 1.4% (s.d.=4.2) of children's total MVPA, respectively, were in these locations.

About 24% of the total sample had reports of ever being in their neighborhood, and 23.8% (n=162) of the sample accrued any MVPA while there. Average daily neighborhood MVPA for all children was approximately 2 minutes, and neighborhood children (those spending any time in their neighborhood) had 8.8 (s.d.=10.8) minutes of neighborhood MVPA. In addition, approximately 54% of the children reported any time at public, outdoor parks & recreation facilities, 38% in private recreation facilities, and 17% in public, indoor recreation facilities.

Table 3.3 presents descriptive statistics of physical activity by location stratified by age-sex. There were no statistically significant differences between any of the age-sex groups for

how children divided their total time at the various locations. There was a general trend in most locations that younger boys relative to their older and female counterparts spent higher percentages of their time engaged in MVPA at most locations, followed by younger girls and then older boys. Across most locations, older girls typically had the lowest percentages of the four age-sex groups. Average daily MVPA at each location had more varying trends by age-sex groups; older children had higher average daily MVPA in the neighborhood relative to their younger counterparts, and boys within each age category had higher average daily MVPA than girls at almost all 12 locations. In their neighborhood, boys 9-11 had an average of 2.6 minutes, girls 9-11 with 2.1 minutes, boys 6-8 with an average of 2.0 minutes, and girls 6-8 with an average of 1.7 minutes (although this was not statistically significant using Bonferroni correction criterion of $p<0.004$). Indeed, younger boys averaged nearly 50% of their neighborhood time as physically active (highest percentage for any age-sex group across locations), whereas less than 10% of the time (lowest percentage for any age-sex group across locations) older girls spent in food eateries was physically active.

Table 3.4 reports the odds of children accruing any neighborhood MVPA relative to children who had no neighborhood MVPA, based on demographic and objective neighborhood characteristics, and parent perceptions of neighborhood. Accounting for all other covariates in the model, there were no significant differences for any given covariate. Odds of accruing any neighborhood MVPA were marginally significantly lower for non-Hispanic non-white children relative to non-Hispanic white children, and marginally higher for parents' self selection of neighborhood, and parents' perceptions of neighborhood aesthetics.

Conducting a multilevel regression with average daily MVPA as the outcome and any neighborhood MVPA as the exposure of interest, neighborhood children had on average 11.2 minutes more of daily MVPA relative to children who had no neighborhood MVPA (p=0.001), after accounting for all other covariates. When neighborhood MVPA was removed from total MVPA and the analysis performed again, there was no longer a statistically significant difference between neighborhood and non-neighborhood children's average daily MVPA (p=0.51). To further delve into why this difference was present, exploratory t-tests were conducted between neighborhood children and non-neighborhood children to determine if there were differences between their MVPA at other specific locations that may also contribute to neighborhood children's higher average daily MVPA. These specific locations were selected: school; public, outdoor parks & recreation facilities; indoor public recreation facilities; and private recreation facilities. No significant differences were found between neighborhood and non-neighborhood children's average daily MVPA at any of the three recreation facility locations. However, there was a significant difference between their average daily school MVPA, with neighborhood children accruing *less* daily MVPA at school, with an average of 33.8 minutes of MVPA each day relative to 39.1 minutes for non-neighborhood children (p=0.03).

Discussion

The primary findings of this study are insights of where children ages 6-11 years old spend their time and where they are active by linking objective physical activity data to time-based reported place logs. Not surprisingly, most of these young children's time and total moderate-to-vigorous physical activity (MVPA) was accrued at home and school. Finding that most of children's total MVPA occurs in the home supports Veitch and colleagues' findings.

They argued that one possible explanation for this is the role of parental rules and concerns with unsupervised physical activity in non-home locations, particularly for younger children. Parents of 6-8 year olds viewed their children as less independent relative to parents with 9-10 year olds, with the latter parent group more likely to allow their children to walk to a friend's house or play in a park unsupervised (Veitch, et al, 2006). Our findings that 9-11 year old children spent more time at other schools and their neighborhood and had higher absolute MVPA in these locations relative to 6-8 year old children fits with this perspective of increased independence with age. The neighborhood and other schools are both locations that have the opportunity for more free play and less structured supervision (e.g. letting a child walk to and play at a local school during after-school hours or ride their bike in the neighborhood).

We also found that younger children and boys relative to girls had on average more MVPA at various locations. This supports previous findings that physical activity seems to decrease as children age and girls continue to lag behind boys in terms of physical activity levels (Nader, et al, 2008; Wall, et al, 2011). Continued effort to provide age- and sex-specific interventions may provide additional benefits to children in these groups (Leek, et al, 2011; Wall, et al, 2011).

Despite the fact that children accrued most of their daily MVPA at home and school, the percentage of time at home and school being active relative to other locations is low. These findings support those by Mackett and colleagues (Mackett, et al, 2005; Mackett & Paskins, 2008). In contrast, although many children spend little to no time in the neighborhood surrounding their homes, their neighborhood time is the most active relative to every other location. Movements like Smart Growth and Active Living aim to promote not only physical

activity and alternative forms of transportation to the automobile but also to improve quality of life and more interactive communities (Geller, 2003). This may be particularly important for children, as evidence suggests interactive communities may ease parental concerns about safety because of other children out in the neighborhood to play with and other adults to help supervise (Franzini, et al, 2010; Veitch, et al, 2006). Informal outdoor play for children moreover provides opportunities for children to enhance other critical developmental areas like creativity (McKendrick & Valentine, 1997). It is noteworthy that public outdoor park and recreation location time had a similarly higher percentage of time in which children were active. Neighborhood and public outdoor park and recreation were the only location categories that were specifically and exclusively outdoor locations. The higher rates of children being active outdoors versus indoors have been documented in other studies (Burdette, Whitaker, & Daniels, 2004; Dunton, Liao, Intille, Wolch, & Pentz, 2011).

The current study found that having any neighborhood MVPA is associated with higher average daily MVPA. These findings are consistent with others' findings of an association between vigorous physical activity and parent report of higher use of the neighborhood to be active (Corder, et al, 2011). Additionally, Mackett et al also found that children ages 10-13 years old expended the most calories per minute (as measured by accelerometer) during informal play settings than any other type of setting, including home, school, and organized club sports (Mackett & Paskins, 2008). We found that after removing the amount of neighborhood MVPA from overall MVPA, there was no longer a difference between neighborhood and non-neighborhood children in overall MVPA. This lends support to the idea that neighborhood children's neighborhood MVPA is not substituting for MVPA in other places, but in fact adds to

their overall MVPA. It is possible that children who are active in their neighborhood are just more active or 'outdoor' children and therefore we might expect higher daily MVPA in all or most physical-activity based locations. However, we did not find evidence to support this, and in fact found only significantly lower MVPA at school for neighborhood children compared to non-neighborhood children.

Collectively, these neighborhood findings raise a key public health policy question of why is the neighborhood underutilized for MVPA despite being easily accessible and affordable? With children, the relevance of adult supervision may remain prominent, and if parents lack time because of work or other commitments, children may continue to spend less time in unstructured locations such as the neighborhood (Brown, Broom, Nicholson, & Bittman, 2010; McKendrick & Valentine, 1997; Veitch, et al, 2006). In conjunction with parent availability, there is evidence that physical activity in structured formats outside of the neighborhood may be increasing for children, and in turn also decreasing the amount of time available to be active in the neighborhood (Carver, Timperio, Hesketh, & Crawford, 2010; Rodriguez, Khattak, & Evenson, 2006; Valentine & McKendrick, 1997). This might be particularly problematic for children's overall physical activity if such opportunities occur at inside and not outdoor venues. Indeed, the percentage of time spent at private recreation facilities was higher than, and for public indoor recreation facilities equal to time spent in the neighborhood. However, the percentage of time children spent being active in these designated recreational locations, particularly the inside locations, was lower than for neighborhood. Time spent at these locations was also markedly lower than amount of time spent in the home. Furthermore, Leek and colleagues found that less than half of the total time during organized children's sports practice was spent engaged in

MVPA and an average of 30 minutes of practice was completely inactive (as measured by accelerometer) (Leek, et al, 2011). This finding not only indicates that there is room to increase MVPA during organized sports practices, but that more time in the neighborhood may lead to a bigger payoff in terms of more MVPA both in time and as previously demonstrated intensity, too (Mackett & Paskins, 2008). It could also be possible that other leisure-time, particularly sedentary activities such as screen time, may keep children at home rather than these other more active locations (Brown, et al, 2010; Corder, et al, 2011; Day, 2006; Hillier, 2008). With the high percentage of time spent in the home though, interventions that increase the appeal of play just outside the home may shift children outside and provide the opportunity to increase children's physical activity and unstructured play.

There are several strengths to this study, including the use of an objective measure of physical activity and examining the relationship between place-based physical activity and several individual, parent perception, and neighborhood factors. In addition, this study used a novel approach to examine where children are active by integrating accelerometer data with prospective parent logging of child whereabouts by time. These findings added additional place categories beyond those previously studied (Corder, et al, 2011; Grow, et al, 2008; Mackett, et al, 2005; Mackett & Paskins, 2008) that included locations that were not inherently physical activity-based (e.g. food eateries, service locations). Moreover, by using accelerometers to measure MVPA, we were able to capture MVPA at all types of locations without relying on parent recall of where and how much their children were active.

Limitations of this study must also be recognized. First, data here are cross-sectional and therefore causality cannot be inferred. Second, our sample was more affluent, well educated and

from two distinctive geographical West Coast locations in the U.S. and our findings therefore have potential generalizability limitations. The nature of our sample may also have contributed in part to the lack of physical activity by location differences by household income and race/ethnicity. A third limitation is that although children were instructed to wear the accelerometer for all waking hours, it is possible that some morning and night time was not captured because the accelerometer was not put on immediately upon waking or taken off immediately prior to going to sleep. Thus, these fragments of waking time are not captured and some of the home time values are likely underestimates (since most days children slept and woke in their own home).

Fourth, as with any self-report or parent-report measures, the surveys and place logs are subject to limitations of accuracy and completeness, but they also serve as a low-cost option with minimal to low participant burden (Sallis & Saelens, 2000). An example of this limitation is often when recording arrival times, parents entered times that may in fact be rounded (e.g. 10:30AM vs. 10:32AM) and therefore small amounts of time may be misattributed to other locations.

Finally, the place logs only asked for arrival time at each location, and therefore any travel time from place to place would be included in the place that preceded the next location. For example, if a child walked from their home to school in the morning, the walking would have been captured in the ‘home’ category. This is an important limitation, as there is value in understanding children’s active transportation to school, and its contribution to children’s overall physical activity estimates (Mackett, et al, 2005; Mackett & Paskins, 2008). In fact, Mackett and Paskins found that children who engaged in active travel were more active at the location they

traveled to versus children who arrived by car (Mackett & Paskins, 2008). Other travel time specifically in public transportation and personal vehicles also would have been captured in location categories and been captured as sedentary behavior.

In our sample, approximately 37% of parents reported that their children walked or rode their bike either to or from school at least once in an average school week, with about 9% reporting active travel to and from every school day (data not shown). Thus, any active travel that occurred while children wore the accelerometer likely would have inflated the percentage of time being active at home and school for these children. Furthermore, any other active travel to neighborhood locations also would have been misattributed and this may have led us to underestimate neighborhood MVPA. On the other hand, our estimate of neighborhood MVPA is "above and beyond" any transit-related MVPA children are getting in their neighborhoods. Incorporating active travel as an additional category of physical activity by location measures would likely benefit future studies.

Investigators are beginning to utilize portable global positioning systems (GPS) in tandem with accelerometers to better understand where people are active and how they utilize alternative modes of transportation (e.g. biking, walking) (see Krenn, et al, 2011 for a review). This method, too, has its limitations including cost, data complexity, and potential participant Hawthorne Effect (participants may be acutely aware of its presence and behave differently) (Troped, Wilson, Matthews, Cromley, & Melly, 2010). As this field of study continues to grow, innovative methods and devices will continue to emerge as a means of better understanding relationships between factors that impact physical activity, active travel, and location of these behaviors.

In the current study, nearly all (~97%) of the children met or exceeded MVPA guidelines, which is in significant contrast to much lower levels noted in previous studies (e.g. Troiano, et al, 2008). A large reason for this is the current moderate activity criteria of 3+ METs. One MET is equivalent to the amount of energy expended at rest, and higher METs are indicative of increased energy expenditure. For youth, trends of using 4+ METs as the cutoff for moderate activity is growing (Corder, et al, 2011; Troiano, et al, 2008; Trost, Loprinzi, Moore, & Pfeiffer, 2011). Still, there remains no set consensus and 3+ METs criteria for youth remains a valid approach (Leek, et al, 2011; Nader, et al, 2008; Wilson, et al, 2011), and our average daily MVPA estimates are similar to those obtained by Nader and colleagues. Additionally, even using 4+METs criteria, children ages 6-11 years are an active age group and have on average daily MVPA levels that surpass 60 minute recommendations, with Troiano and colleagues reporting 95.4 minutes for boys and 75.2 minutes for girls in this age group (Troiano, et al, 2008). Finally, the Freedson age-based cut points used in the present study have been found to have excellent accuracy in classifying sedentary, light, and MVPA. (Trost, et al, 2011).

Future studies that focus on youth populations who are not currently meeting guidelines of at least 60 minutes of MVPA every day and their neighborhoods may provide additional insight into the current study's finding of the relationship between neighborhood MVPA and average daily MVPA. Policy and research focused on creating policies and interventions that increase children's time spent in the neighborhood may be associated with higher overall levels of neighborhood MVPA and average daily MVPA. The current study did not find any statistically significant associations between demographic, parent perception, and neighborhood factors as they relate to children accruing any MVPA in the neighborhood. This makes it

challenging to know what specific types of interventions would increase neighborhood MVPA. Additional qualitative and community-based participatory research may provide insight into factors deemed most relevant by parents that will increase their children's physical activity in the neighborhood.

Acknowledgments

This project was supported by Grant #UL1RR025014 from the National Center for Research Resources (NCRR), a component of the National Institutes of Health (NIH), and NIH Grant #ES014240.

The authors wish to thank Dr. Trina Colburn for her general assistance and insight into the NIK Study, and Olga Vitruk for her assistance in coding place categories to assess for inter-rater reliability.

Table 3.1. Demographic Characteristics of Study Sample		
Child age, Mean (SD)		9.1 (1.6)
Child sex, n, (%)	Male	342 (50.2)
	Female	340 (49.9)
Child race/ethnicity, n, (%)	Non-Hispanic white	462 (67.7)
	Hispanic	116 (17.0)
	Non-Hispanic non-white	104 (15.3)
Highest education level in household[a], n, (%)	< 7th grade	2 (0.3)
	Jr. high/middle school	4 (0.6)
	Some high school	8 (1.2)
	Completed high school	21 (3.1)
	Some college	112 (16.7)
	Completed college	273 (40.7)
	Completed graduate school	251 (37.4)
Household income[b], n, (%)	<$50k	92 (13.9)
	$50-100k	245 (37.1)
	>$100k	324 (49.0)
Neighborhood physical activity environment (PAE), n, (%)	Low PAE	329 (48.2)
	High PAE	353 (51.8)
County, n, (%)	San Diego County	327 (48.0)
	King County-Seattle	355 (52.1)
Child average daily MVPA, minutes, Mean (SD)		144.0 (52.0)

Abbreviations: SD, standard deviation; PAE, physical activity environment; MVPA, moderate-to-vigorous physical activity.

[a] n=671 participants whose parents reported household education

[b] n=661 participants whose parents reported household income

Table 3.2. Descriptive Statistics for 6-11 Year Old Children's Physical Activity by Location

Location	Average % of total time at each location (SD)	Average % of total time spent at each location engaged in MVPA (SD)	Average daily MVPA at each location, minutes (SD)
Home	47.5% (15.4)	18.2% (8.3)	62.6 (36.7)
School	29.0% (17.1)	18.1% (8.2)	37.6 (27.4)
Others' Homes	6.5% (7.8)	22.0% (13.2)	10.1 (13.8)
Service Locations	5.8% (7.3)	16.6% (11.6)	8.0 (14.9)
Public, Outdoor Parks & Rec.	2.6% (4.1)	39.7% (20.1)	6.9 (10.9)
Shopping	2.4% (3.0)	19.1% (10.7)	3.2 (4.7)
Other Schools	1.6% (4.0)	29.8% (19.5)	3.3 (8.1)
Food Eateries	1.4% (1.9)	13.2% (11.2)	1.3 (2.3)
Private Rec. Facilities	1.4% (2.8)	30.1% (16.0)	3.1 (6.4)
Public, Indoor Rec. Facilities	0.8% (3.2)	31.9% (17.4)	1.8 (8.0)
Neighborhood	0.8% (2.7)	42.1% (23.7)	2.1 (6.5)
Nondescript Geographical Locations	0.2% (1.7)	31.3% (23.4)	0.4 (3.7)
Total	100.0%		140.4 minutes[a]

[a]=Total moderate-to-vigorous physical activity does not match that of Table 3.1, because valid day criteria differed between place-based MVPA estimates and total MVPA estimates (see Methods section)

Table 3.3. Descriptive Statistics for Children's Physical Activity by Location, Stratified by Sex & Age

Location		Average % of total time at each location (SD)		Average % of total time spent at each location engaged in MVPA (SD)		Average daily MVPA at each location, minutes (SD)	
		Boys	Girls	Boys	Girls	Boys	Girls
Home	6-8 years old	48.1% (16.3)	48.7% (14.7)	23.8% (7.4)[c,d]	21.8% (7.2)[c,d]	83.4 (40.4)[c,d]	76.2 (33.8)[c,d]
	9-11 years old	46.4% (15.7)	46.7% (14.9)	14.9% (7.1)[a,b]	12.4% (5.4)[a,b]	50.3 (31.2)[a,b]	41.0 (21.3)[a,b]
School	6-8 years old	28.0% (17.6)	28.6% (16.7)	23.4% (8.5)[c,d]	20.4% (7.9)[c,d]	46.9 (33.5)[c,d]	41.4 (28.6)[d]
	9-11 years old	29.6% (17.2)	29.9% (17.1)	15.9% (5.4)[a,b]	13.4% (6.9)[a,b]	34.4 (23.5)[a]	28.0 (18.4)[a,b]
Others' Homes	6-8 years old	6.1% (8.0)	6.4% (8.6)	27.3% (14.1)[c]	25.0% (13.0)[c,d]	12.6 (18.7)	11.1 (13.8)
	9-11 years old	6.5% (7.1)	6.9% (7.5)	20.7% (13.3)[a]	15.8% (9.3)[a,b]	9.2 (11.2)	7.7 (9.3)
Service Locations	6-8 years old	6.4% (8.9)	5.9% (7.0)	22.1% (12.4)[c,d]	19.4% (12.0)[c,d]	12.0 (22.0)[c,d]	9.0 (15.4)
	9-11 years old	5.4% (6.6)	5.4% (6.3)	13.7% (9.5)[a,b]	11.3% (8.9)[a,b]	6.2 (10.1)[a]	4.9 (7.2)[a]
Public, Outdoor Parks & Rec.	6-8 years old	2.8% (3.9)	2.2% (4.6)	46.0% (19.9)[d]	43.5% (21.4)[d]	8.5 (11.9)[d]	5.8 (10.7)
	9-11 years old	3.4% (4.2)	2.0% (3.3)	38.0% (18.1)	31.0% (18.2)[a,b]	8.9 (12.1)[d]	4.2 (7.5)[a,c]

Table 3.3. Descriptive Statistics for Children's Physical Activity by Location, Stratified by Sex & Age, continued

Shopping	6-8 years old	2.3% (3.0)	2.8% (3.3)	23.8% (11.3)[c,d]	22.3% (10.7)[c,d]	3.8 (5.7)[c]	4.4 (5.9)[c,d]
	9-11 years old	2.0% (2.8)	2.5% (2.7)	15.9% (8.8)[a,b]	14.3% (8.5)[a,b]	2.1 (2.8)[a,b]	2.4 (3.0)[b]
Other Schools	6-8 years old	1.2% (3.9)	1.0% (3.8)	38.8% (19.8)	28.6% (18.2)	3.4 (8.4)	2.0 (7.1)
	9-11 years old	2.3% (4.7)	1.7% (3.3)	30.3% (19.0)	23.5% (18.4)[a]	4.7 (9.3)	3.1 (7.4)
Food Eateries	6-8 years old	1.5% (1.9)	1.3% (2.0)	15.1% (10.7)	16.2% (13.3)[d]	1.8 (3.0)	1.3 (2.2)
	9-11 years old	1.1% (1.5)	1.5% (1.9)	11.7% (12.0)	9.8% (7.0)[b]	0.9 (2.0)	1.1 (1.9)
Private Rec. Facilities	6-8 years old	1.2% (2.5)	1.4% (2.8)	34.2% (14.3)	34.7% (15.1)[c]	3.2 (6.5)	3.4 (6.0)
	9-11 years old	1.3% (2.5)	1.7% (3.4)	24.9% (16.2)[b]	26.4% (15.9)	2.4 (4.8)	3.3 (7.9)
Public, Indoor Rec. Facilities	6-8 years old	1.2% (4.4)	0.8% (3.6)	35.3% (17.2)	33.2% (19.5)	3.0 (11.9)	1.8 (7.0)
	9-11 years old	0.7% (2.5)	0.4% (1.7)	31.0% (16.5)	24.5% (14.0)	1.7 (6.3)	0.9 (5.4)
Neighborhood	6-8 years old	0.6% (1.7)	0.6% (1.6)	49.8% (20.8)	45.7% (23.8)	2.0 (5.3)	1.7 (5.3)
	9-11 years old	1.1% (3.7)	1.1% (3.0)	40.6% (22.7)	35.5% (25.0)	2.6 (9.1)	2.1 (5.2)
Nondescript Geographical Locations	6-8 years old	0.4% (2.7)	0.1% (1.2)	43.6% (22.0)	34.3% (27.0)	0.9 (6.3)	0.3 (2.6)
	9-11 years old	0.2% (1.2)	0.2% (1.4)	28.3% (15.5)	11.0% (18.7)	0.4 (2.6)	0.1 (1.2)

Table 3.3. Descriptive Statistics for Children's Physical Activity by Location, Stratified by Sex & Age, continued

Total	6-8 years old	99.8%[e]	99.8%[e]			181.5 minutes	158.4 minutes
	9-11 years old	100.0%	100.0%			123.8 minutes	98.8 minutes

[a]=significantly different from boys 6-8 years old; [b]=significantly different from girls 6-8 years old; [c]=significantly different from boys 9-11 years old; [d]=significantly different from girls 9-11 years old, with $p<0.004$ Bonferroni correction for multiple tests

[e]=Total not equal to 100% because of rounding

Table 3.4. Multilevel Odds Ratios (95% CI) of Children Accruing Any Neighborhood MVPA by Individual, Household, and Neighborhood Characteristics

	OR (95% CI)	p-value
Individual & Household Characteristics		
Age, years	1.06 (0.94, 1.20)	0.34
Sex[a]	1.14 (0.79, 1.66)	0.48
Race/Ethnicity[b]		
Hispanic	1.04 (0.59, 1.83)	0.90
Non-Hispanic non-white	0.55 (0.30, 1.01)	0.05
Highest HH education	0.96 (0.75, 1.22)	0.72
HH income[c]		
$50k-100k	1.61 (0.80, 3.26)	0.18
>$100k	1.75 (0.82, 3.74)	0.15
Prior crime victimization[d]	1.21 (0.75, 1.95)	0.45
Self-selection for neighborhood walkability	1.27 (1.00, 1.59)	0.05
Neighborhood Characteristics		
Neighborhood PAE[e]	1.07 (0.70, 1.64)	0.75
Neighborhood Median HH income	1.00 (1.00, 1.00)	0.91
Parents' Perceptions		
Collective efficacy	1.22 (0.87, 1.72)	0.25
Neighborhood aesthetics	1.38 (0.98, 1.93)	0.07
Traffic safety	1.29 (0.82, 2.04)	0.28
Land use mix access	0.84 (0.62, 1.12)	0.23

Table 3.4. Multilevel Odds Ratios (95% CI) of Children Accruing Any Neighborhood MVPA by Individual, Household, and Neighborhood Characteristics, continued		
Street connectivity	0.93 (0.71, 1.20)	0.56
Bike/pedestrian infrastructure	1.22 (0.95, 1.56)	0.13
Recreation facility availability	1.04 (0.96, 1.13)	0.32
Land use mix diversity	0.99 (0.93, 1.06)	0.87
Stranger danger	0.93 (0.70, 1.24)	0.64
General crime & disorder	1.07 (0.70, 1.64)	0.75

Abbreviations: OR, odds ratio; CI, confidence interval; MVPA, moderate-to-vigorous physical activity; HH, household; PAE, physical activity environment

[a]referent category=male; [b]referent category=non-Hispanic white; [c]referent category=<$50k HH income; [d]referent category=no prior victimization; [e]referent category=low PAE

Chapter 4: Associations Between Neighborhood Crime, Parents' Safety Perceptions, and Children's Physical Activity

Introduction

Neighborhood crime is both a societal safety issue and public health issue. Not only can it directly harm residents through its violent manifestations, but it can also indirectly harm residents through stress and impacts on health outcomes and health behaviors. In particular, many researchers have started to examine the relationship of neighborhood crime and its potential impact on residents' physical activity (Badland et al, 2009; Bennett et al, 2008; Carver et al, 2008; Diez-Roux et al, 2007; Duncan et al, 2009; Foster & Giles-Corti, 2008; Gomez, Johnson, Selva, & Sallis, 2004; Lopez & Hynes, 2006; Loukaitou-Sideris, 2006; Neckerman et al, 2009; Orleans et al, 2003; Roman, Knight, Chalfin, & Popkin, 2009; Romero, 2005). Issues of crime and safety may be especially pertinent to children's physical activity, as children are seen as more vulnerable and through parent supervision and control may be precluded from moving freely through or being within areas perceived as unsafe.

Crime may influence children's PA through several potential mechanisms. First, high rates of crime in a child's neighborhood may lead to increased exposure of crime through witnessing, victimization, or hearing about victimization (Bursik & Grasmick, 1993; Carver, et al, 2008; Foster & Giles-Corti, 2008; Loukaitou-Sideris, 2006; Loukaitou-Sideris & Eck, 2007; Roman, et al, 2009; Sun, Triplett, & Gainey, 2004; Valentine & McKendrick, 1997). Prior crime victimization of self or known others may play a mediating role in parents' perceptions of neighborhood crime. It has been suggested that those who previously have been victimized may have a stronger negative perception of neighborhood crime and violence than those who have never been victimized and do not know anyone personally who was previously been victimized

(Bursik & Grasmick, 1993; Carver et al, 2008; Loukaitou-Sideris & Eck, 2007; Sun et al, 2004). This increased exposure or victimization may heighten parents' fears of crimes occurring against their children.

Second, parents' safety perceptions may play a role in children's physical activity, particularly activity in their neighborhood. Parents' perceptions that the neighborhood is unsafe may lead to parents limiting children's time spent in the neighborhood and constrain their physical activity to indoor or non-neighborhood locations (Carver et al, 2008; Carver, Timperio, Hesketh, & Crawford, 2010; Committee on Environmental Health, 2009; Gomez, et al, 2004; Hillier et al, unpublished; Lopez & Hynes, 2006; Loukaitou-Sideris, 2006; Loukaitou-Sideris & Eck, 2007; Valentine & McKendrick, 1997; Weir, Etelson, & Brand, 2006). Additionally, it has been noted that parents who worry about children's safety from crime prefer to keep a watchful eye on children within the confines of their home, perhaps resulting in sedentary behavior (i.e. 'screen time') over physical activity as a resulting consequence (Brown et al, 2008; Hillier, 2008; Lopez & Hynes, 2006; Valentine & McKendrick, 1997; Williams & Green, 2001). Children may be further restricted to their homes if parents do not have time and resources to supervise their children and therefore must relent to having children stay in a known safe place (i.e. the home) while unsupervised (Brown, Broom, Nicholson, & Bittman, 2010).

A third potential process in which neighborhood crime is related to children's physical activity is through indirect exposure to crime. Tell-tale signs of crime (often termed 'incivilities') such as graffiti, broken glass and other signs of social or physical disorder may increase parents' perceptions of the presence of crime, regardless of direct witnessing or victimization of any actual crimes committed (Bursik & Grasmick, 1993; Foster & Giles-Corti, 2008; Loukaitou-

Sideris, 2006; Loukaitou-Sideris & Eck, 2007; Mijanovich & Weitzman, 2003; Roman et al, 2009; Williams & Green, 2001). Consistent presence of these incivilities in the neighborhood may again heighten parents' fears that crime is 'just around the corner', and that children lack judgment about dangerous situations and are without means to defend themselves (Bursik & Grasmick, 1993; Mijanovich & Weitzman, 2003; Valentine & McKendrick, 1997). In addition, the incivilities may directly pose a risk to the child's safety (e.g. broken glass and drug paraphernalia that may cause injury) (Lopez & Hynes, 2006). Thus, as a means of protecting their children from both criminal behavior and incivilities, parents may feel that children are safer remaining within the home potentially resorting to sedentary activities, thus decreasing their physical activity both in the neighborhood and in general (Brown et al, 2008; Hillier, 2008).

Crime can be measured in several different ways. Bursik and Grasmick identify the following five basic approaches to measuring neighborhood crime: official statistics collected by law enforcement agencies, self-report of offending, self-report of fear and victimization, ethnographic community studies, and calls to police by citizens (Bursik & Grasmick, 1993, p. 22). These various crime measures may provide unique insight into the relationship between neighborhood crime and different health behaviors such as physical activity. The present study used five types of crime measurements: police-reported crimes, incivilities as measured via pedestrian audits, and parent reports of three different perceptions of aspects of crime and victimization. This allowed us to provide a comprehensive picture of crime and its potential role in children's physical activity.

Research on crime and/or parents' perceptions of crime and children's physical activity remains mixed with some finding no relationship (Babey, Hastert, Huang, & Brown, 2009; Kerr

et al, 2006). Some have suggested that measurement differences may play a role in these mixed findings (Day, 2006; Foster & Giles-Corti, 2008), while others have noted little variation in their crime measures (Day, 2006; Hillier et al, unpublished; Pikora et al, 2006). Furthermore, different measures of crime may not be correlated with one another, and they may also measure unique (and equally) important concepts that impact physical activity distinctively. Thus, it is important to examine the potential associations between different measures of crime and their relationships with children's physical activity. Few studies have examined both official crime statistics and residents' safety perceptions simultaneously in relation to physical activity (Bennett et al, 2008; Dannenberg et al, 2003; Duncan et al, 2009; Foster & Giles-Corti, 2008; Gomez et al, 2004).

The aims of this study are two-fold: to evaluate a comprehensive set of five neighborhood crime measures to determine if and how they are interrelated; and to explore how any or all of these crime measures are cross-sectionally related to children's overall moderate-to-vigorous physical activity (MVPA), and MVPA that occurs exclusively in their neighborhood.

Methods

Study Design

The current study used baseline data from a sub-cohort of 6-11 year old children living in San Diego, CA, from an observational prospective cohort study titled the Neighborhood Impact on Kids (NIK) Study. The NIK Study examined neighborhood and individual factors related to weight and weight-related behaviors (i.e. physical activity and nutrition behaviors).

This study was approved by the Institutional Review Boards at Seattle Children's Hospital and San Diego State University.

Neighborhood Selection

Details of neighborhood selection for the overarching NIK study are described elsewhere (Saelens, et al, unpublished), but briefly, neighborhood was defined as a census block group. Prior to participant recruitment, neighborhoods were evaluated based on several built (e.g., availability of higher quality parks) and nutrition (e.g., presence of a grocery store or supermarket) environment characteristics in King County, WA, and San Diego County, CA using information brought into Geographic Information Systems (GIS). Neighborhoods were divided into one of four neighborhood quadrants based on the presence and quality of environmental characteristics either supportive or unsupportive of physical activity and/or nutrition: high physical activity environment (PAE)/high nutrition environment (NE); high PAE/low NE; low PAE/high NE; and low PAE/low NE.

Participants & Recruitment

Details of the recruitment and study data collection procedures are described elsewhere (Saelens, et al, unpublished). Briefly, between September 2007 and January 2009, participants were contacted and recruited from households within the identified neighborhoods. To be eligible, children had to be between the ages of 6 and 11 years old and have a parent or legal guardian also willing to participate. In addition, only one child per household was permitted to participate. Children had to be able to engage in moderate-to-vigorous physical activity and meet additional inclusion and exclusion criteria related to healthy growth and not be below the 10th percentile of body mass index for age and sex based on parent report of child weight and height (Saelens, et al, unpublished).

An additional inclusion criterion for the present study was that participants must reside in the City of San Diego and have police-reported crime data obtained from the San Diego Police

Department. 150 participants living within 103 census block groups had geocoded police-reported crime data. Of those 150 participants, 5 participants did not have corresponding parent-reported place logs for their physical activity data (described below), resulting in a final sample of 145 participants within 99 census block groups.

Measures

Field-based observation to measure neighborhood qualities and incivilities

Based on the various existing pedestrian audit tools, the research team developed an audit tool to examine community- and street-scale factors relevant to participants' neighborhood built and social environments. For each participant, a ¼ mile route was selected originating from the participant's home address and heading in the direction of the closest commercial destination or park. Staff measured several permanent, transient, and social environmental factors via direct observation to capture a microscale snapshot of various neighborhood qualities. Staff were trained prior to auditing participants' neighborhoods. Field-based audit data were collected between June 2009 and November 2009.

Along the ¼ mile audited route of each participant's home, several factors proposed to represent incivilities chosen *a priori* based on past literature were derived from the field-based audit tool (Foster & Giles-Corti, 2008; Neckerman, et al, 2009). The items included in the incivilities measure and their scoring are described below.

The following three location types were assessed as 0, 1, 2 or more present: liquor/alcohol stores, abandoned buildings, and unmaintained lot/field. For this section of 'incivilities' locations, a score of 0, 1, or 2 for 2+ locations present were assigned in-line with number of locations present, yielding a possible score of 0 to 6 for this section. Street lights

along the route were assessed as either being not present, some (e.g., overhead street lights on utility poles with wide spacing), or ample (e.g., regularly spaced pedestrian lampposts). This item was reverse-scored so that no lights present was assigned a 2, some lighting a 1, and ample lighting a 0, for a possible score of 0 to 2. The presence of ten physical disorders (yes/no) assessed were: graffiti/tagging (not murals); abandoned cars; buildings with broken/boarded windows; drug paraphernalia; broken glass; beer/liquor bottle/cans; litter in yards; noticeable/excessive litter in street/sidewalk; neighborhood watch signs; signage for commercial destinations or parks. All items were assigned a score of 0 if absent, 1 if present, with the exception of neighborhood watch signs and signage for commercial destinations or parks, which were reverse-scored, giving this section a total possible score of 0 to 10. Finally, the ratings for the extent of both physical (the ten disorders listed above) and social disorder (e.g. stray dogs, gangs, prostitutions, hostile behaviors, drug dealing, panhandlers, etc.) present were assessed as none, a little (physical/social disorder is present), some (disorder is very noticeable), or a lot (disorder is overwhelming). These two items were each scored as 0 for no disorder present, 1 for a little, 2 for some, and 3 for a lot, giving a possible score of 0 to 6 for this section. Scores were summed to create a total incivilities score, with higher scores indicating a greater presence of incivilities. Total scores had a possible range of 0 to 24.

Geocoding police-reported crime data

The City of San Diego's Police Department provided a short description, crime category, and nearest cross-streets for crimes reported between 2007 and 2009, with a total of 245,174 crimes during that period. Regardless of type of crime, nearest cross-streets of where crimes occurred were geocoded using ArcGIS v.10, with an initial match rate of 92% (224,693 police-

reported crime point data), 1% tied (1,252 point data) and 8% unmatched (19,229 point data). Tied and unmatched police-reported point data were reviewed for spelling and ambiguous addresses and geocoded again, yielding a final match rate of 97.6% (239,268 police-reported crime point data). X and Y coordinates of the final matched police-reported crime point data were obtained using the geometry calculator in ArcGIS, converting the geocoded point data into x and y coordinates in 1984 World Geodetic System (WGS) decimal degrees.

2000 census block group boundaries and data for San Diego County were retrieved to sum police-reported crime data to the block group level (US Census, 2011). For each year (i.e. 2007-2009), geocoded police-reported crime point data were matched to their respective census block group using the spatial join function in ArcGIS. Crime frequencies for each year were summed by block group and averaged over the three years to obtain an average yearly estimate of total number of police-reported crimes for each census block group.

Outcome Measures

Physical activity

Children's physical activity was measured by the MTI (formerly CSA) GT1M Actigraph accelerometer. The Actigraph has been validated and calibrated for use among children (Freedson, et al, 1997). Accelerometers were initialized to sample and store activity counts beginning at 00:00:01 (i.e. 12:00:01AM) on the first day of expected wearing. Participants were asked to wear the accelerometer for seven days, for at least 10 hours per day, during their waking hours. Upon return, the accelerometer was downloaded and screened for completeness and possible irregularities or malfunction. Participants were asked to re-wear the accelerometer if it

was not worn for enough valid hours on at least 6 days. A valid hour was defined as one that had no more than 20 minutes of consecutive zero counts.

Physical activity count data were captured in 30-second epochs (with higher counts indicative of increased acceleration). These counts in turn were converted into activity intensity by using pre-established cut points (Freedson et al., 1997). Age-specific cut points were employed, with moderate-intensity activity defined as 3 METs up to vigorous-intensity, defined as 6 METs or greater. Participants' ages were rounded to a half-year.

Average daily moderate-to-vigorous physical activity (MVPA) was calculated by summing only MVPA that accrued on days that had at least 8 valid hours of wear time and dividing by the total number of days that met that criterion. Only participants with at least 3 valid days of 10+ hours were included (n=142) in the present analysis.

Average daily neighborhood MVPA was calculated by summing all moderate-to-vigorous intensity minutes that occurred in the neighborhood per parent-reported place log and dividing across the total number of days that the child had any accelerometer wear time. In the place log instructions, neighborhood was defined as an area around the home or neighborhood but was not a specific place with an address. Methods for summing objective physical activity by location are described elsewhere (Kneeshaw-Price, et al, unpublished). The valid wear time criterion described for total average daily MVPA was relaxed here and all participants with physical activity by location data were included in this measure (n=145). Of the three children who did not meet this criterion, one child had 1 10+ valid hour day and 5 8+ (but less than 10) valid hour days; a second child had 2 10+ valid hour days and 3 8+ valid hour days; and the third child had no 10+ valid hour days, 3 8+ valid hour days, and 5 days with less than 8 valid hours.

Key Exposure Measures

Parents' perceptions of neighborhood crime: Stranger danger and General crime & disorder

Parents completed a survey (online or paper) that included items about neighborhood perceptions, household, and parent and child demographics. Parents' perceptions of neighborhood crime were assessed using nine questions and included questions such as, "I am afraid of my child being taken or hurt by a stranger on local streets" and "There is a high crime rate [in my neighborhood]" with four possible responses ranging from strongly disagree to strongly agree (see Table 4.1). A principal component factor analysis was performed on the full NIK sample (n=730), with an oblique rotation (assuming that any factors that loaded were correlated with one another). This resulted in two parent perception factors with eigenvalues greater than 1.0 titled *stranger danger* and *general crime and disorder*. These factors were found to have good and acceptable internal consistency, respectively. Ratings for questions on each factor were averaged to create summary variables, with higher scores indicating a higher parental concern of that crime factor in the neighborhood.

Prior crime victimization

Parents responded to two survey questions asking if they 1) had ever been a victim of crime in their neighborhood and 2) if they knew someone who had been a victim of crime in their neighborhood with responses on a four-point Likert scale ranging from 'strongly disagree' to 'strongly agree.' Based on prior work by Foster and colleagues (Foster, Giles-Corti, & Knuiman, 2010), the dichotomized any prior victimization variables was created, considered present if parents responded with 'somewhat agree' or 'strongly agree' to either or both questions.

Adjustment Measures

Demographic covariates

Demographic variables assessed by parent-reported survey included child's age sex, race/ethnicity (categorized as non-Hispanic white, Hispanic, and non-Hispanic non-white), and household income (categorized as <$50k, $50-100k, and >$100k).

Collective efficacy

Previously created and used by Sampson and colleagues, a single summary variable comprised of two scales, social cohesion and informal social control, was created to evaluate collective efficacy (Sampson, et al, 1997). Items were reverse coded where necessary with higher values representing higher collective efficacy, and the variable was the average of eleven parent survey questions such as "people in my neighborhood can be trusted" and how likely would neighbors respond if "they witness a crime in progress". These scales have been found to represent similar constructs and were also combined by their originators (Sampson, et al, 1997). They also have been found to have acceptable to good internal reliability (Franzini, et al, 2010).

Collective efficacy was included because it may play a role in a relationship between neighborhood crime and children's physical activity. It is possible that it discourages neighborhood crime (e.g. neighbors do not hesitate to alert authorities should they witness a crime in progress) (Bursik & Grasmick, 1993; Foster & Giles-Corti, 2008; Lopez & Hynes, 2006; Sampson, et al, 1997; Sun et al, 2004; Williams & Green, 2001) and/or increases children's physical activity (e.g. parents allow their children to play in the neighborhood partially because of the knowledge that there are other adults available to supervise children) (Veitch, Bagley, Ball, & Simon, 2006).

Neighborhood physical activity environment

Neighborhood physical activity environment (PAE) was dichotomized into high physical activity environment and low physical activity environment by combining the neighborhood quadrants (foregoing level of nutrition environment) previously defined to identify NIK neighborhoods.

Data Analyses

All analyses were conducted using STATA 11 SE. Descriptive statistics for demographics were calculated, as well as for the crime measures and collective efficacy, presented in Tables 4.2 and 4.3, respectively. Pearson's product-moment correlations between the measures of crime and moderate-to-vigorous physical activity (MVPA) were performed to examine the relationship between the crime measures and MVPA in the neighborhood and overall. Children's total and neighborhood MVPA were also reported by police-reported crime quartiles (Table 4.4).

Subsequently, two separate multilevel linear random effects models using robust standard errors with two levels (child, and census block group as the clustering variable) were estimated to explore whether any of the crime measures were significantly associated with child average daily MVPA and child average daily neighborhood MVPA in minutes. The following basic model was of interest:

$$y_{ij}=\beta_0+\beta_1 \text{Police-reportedCrime}_{ij}+\beta_2 \text{Incivilities}_{ij}+\ldots+\beta_{11} \text{Child'sAge}_{ij}+\varepsilon_{ij},$$

where y_{ij}=average daily minutes of MVPA for child j in neighborhood i, and $\varepsilon_{ij}=b_i+e_{ij}$, where $b_i \sim N(0, \varphi^2)$ and $e_{ij} \sim N(0, \theta^2)$; b_i is the neighborhood random variance, and e_{ij} is the individual deviation from the neighborhood mean ($e_{ij} \sim N(0, \theta^2)$). φ^2 is the between-cluster

variance and θ2 is the within-cluster variance; the total variance is the sum of these two variances. The assumptions of this model are that: the neighborhoods are a random sample from a larger population of neighborhoods; individual observations, children, within a neighborhood are *not* independent; and that there is sufficient power to detect any significant differences. In addition, "individual errors within each group are assumed to be independent and normally distributed", and neighborhood random variance are assumed to be independent of individual errors and independent of each other and normally distributed (Diez-Roux, 2000, p. 174).

Because these models take a socioecological approach where more distal environmental factors' associations with child physical activity may be mediated by more proximal parents' perceptions and prior crime victimization, these models were run in five stages, with the environmental factor furthest away from the individual entered first (i.e. police-reported crime), and the most directly-related crime measure entered last (i.e. prior crime victimization). This allowed us to view any association of these individual-level crime covariates as they were entered into the model on the environmental factors' coefficients. The five stages were as follows: 1. Police-reported crime alone as the exposure of interest; 2. Police-reported crime and neighborhood incivilities; 3. Police-reported crime, incivilities, and parents' perceptions of crime; 4. Police-reported crime, incivilities, parents' perceptions of crime, and prior crime victimization; and 5. All crime measures with adjustment for collective efficacy and demographic covariates. All significance levels were set at alpha<0.05.

Results

Average daily moderate-to-vigorous (MVPA) for the sample was 135.9 (s.d.=49.4) minutes, and average daily neighborhood MVPA was 1.7 (s.d.=5.8) minutes. Only 20% of the

sample had any neighborhood MVPA at all, and among these children the daily neighborhood MVPA average was 8.3 (s.d.=10.9) minutes.

The average yearly number of police-reported crimes was 87.7 (s.d.=98.0) crimes per block group per year. In general, the sample had on average low neighborhood incivilities identified by the audit tool. Parents' perceptions of stranger danger and general crime and disorder were generally low, indicating on average a slight concern of stranger danger and less concern or perception of general crime and disorder. More than a quarter of the sample reported experiencing or knowing someone who experienced victimization in their neighborhood. Parents' also perceived relatively high collective efficacy in their neighborhood (see Table 4.3).

Children living in neighborhoods in the lowest police-reported crime quartile had the highest total and neighborhood MVPA compared to children living in other neighborhoods in the higher quartiles, while children in the highest crime quartile had the lowest (Table 4.4). However, there was not a downward linear trend in MVPA as quartiles increased. Interestingly, when children were further divided into neighborhood and non-neighborhood children, neighborhood children living in neighborhoods in the highest police-reported crime quartile had much lower total MVPA than non-neighborhood children living in the same quartile of crime neighborhoods.

Bivariate correlations between crime and MVPA measures are presented in Table 4.5. More neighborhood incivilities were significantly associated with higher parent perceptions of general crime & disorder. Additionally, parents' perceptions of general crime & disorder were positively and significantly associated with parents' concerns about stranger danger. Finally, prior crime victimization was positively and significantly associated with neighborhood

incivilities, and parent concerns about stranger danger and general crime and disorder. No other associations between the crime measures were statistically significant.

After accounting for all other crime measures and covariates, an increase in one additional police-reported crime in the census block group was associated with significant decreases of 0.09 average daily total MVPA minutes (p=0.005) (Table 4.6). None of the other crime measures were independently related to total MVPA. In the fully adjusted model, relative to boys, girls had significantly lower average daily MVPA of almost 17 minutes less (p<0.001), and each year increase in age was associated with 18 less daily MVPA minutes (p<0.001).

After accounting for all other crime measures and covariates, average daily neighborhood MVPA was significantly lower by 0.01 minutes for each additional police-reported crime (p=0.02) (Table 4.7). None of the other crime measures were independently related to neighborhood MVPA. In this model, boys had on average 2 minutes more of neighborhood MVPA than girls (p=0.02) and children living in a high neighborhood physical activity environment (PAE) had over 3 minutes more of neighborhood MVPA relative to children living in a low neighborhood PAE (p=0.005).

Discussion

The primary finding of this study is that higher police-reported crimes in the neighborhood, after accounting for other crime variables and demographics, is associated with less child overall moderate-to-vigorous physical activity (MVPA) and specifically lower child MVPA within the neighborhood. This study also found that the presence of more neighborhood incivilities are associated with parents' prior crime victimization, and greater parents' perceptions of general crime and disorder in the neighborhood, and that parents' perceptions of

general crime and disorder are also associated with their perceptions of stranger danger. In addition, prior victimization was also associated with both parents' crime perceptions, with the strongest relationship among the crime measures being between parents' prior victimization and their perceptions of general crime and disorder in the neighborhood. However, none of the parent perceptions of crime or the objectively measured incivilities were independently or collectively related to children's physical activity.

Police-reported crime at the census block group level appears to be associated with children's MVPA, both in total and in the neighborhood. Reducing violence perpetuated by neighborhood crime is gaining relevance as a target for improving children's health behaviors (i.e. physical activity and healthy eating) and decreasing risk for related chronic illnesses (Cohen, Davis, Lee, & Voldovinos, 2010). Recommendations for addressing the link between crime and active neighborhood living include championing the importance of addressing this relationship and community partnering with residents and professionals across public health, planning, and criminology, among other disciplines.

To our knowledge, this is the first study to link actual crime data at the neighborhood level to neighborhood physical activity among children. In the current study, all police-reported crimes were included in the measure, some of which may not have as great of an impact on children's physical activity (e.g. fraud). Past studies have noted that the types of crime and the potential risks they pose to a child's safety (e.g. illegal gambling vs. aggravated assaults) may influence the degree of fear a parent experiences and in turn limits their child's activity (Brown, et al, 2008; Bursik & Grasmick, 1993; Hillier et al, unpublished; Loukaitou-Sideris & Eck, 2007; Valentine & McKendrick, 1997). Although we were given information about the specific crimes

that occurred and could have filtered out crimes that *a priori* seemed less relevant to children's MVPA, this study was meant to be a broader exploration of several different crime measures simultaneously with no assumptions of which types of crime might be related to children's physical activity. Future studies distinguishing between these types of crime are warranted. It may be prudent to conduct a qualitative study specifically asking parents about various types of crimes and which and at what level they feel would concern them enough to restrict their children's time in the neighborhood.

Our findings also suggest that the presence of incivilities within a neighborhood may not go unnoticed by parents, which in turn are associated with their perceptions of greater crime and disorder in their neighborhood. This supports a 'disorder model,' which posits that the presence of incivilities signals to residents a general breakdown of the neighborhood and symbolizes threats to personal safety, in turn increasing perceptions and fear of crime and social disorder (Bursik & Grasmick, 1993). In addition, it appears that prior victimization may color perceptions of crime, with more concerns about safety about the neighborhood as a whole present in those who have experienced or know someone who has experienced crime victimization, as previously demonstrated by others (Foster, et al, 2010).

Although most of the crime measures were not statistically associated with children's MVPA in the present study, parents' perceptions have been found to serve as a filter for their children's physical activity in previous studies (Weir, et al, 2006). The lack of statistically significant findings for the other measures of crime included in the study may be an issue of lack of variability, as previously noted by others (Day, 2006; Hillier et al, unpublished; Pikora et al, 2006). In the present study, neighborhood incivilities and both parents' crime perceptions were

low on average with relatively low variability across neighborhoods whereas there was greater variability in the police-reported crime measure across neighborhoods. Future studies that select participants' neighborhood based on higher variability in these crime measures may provide different effect estimates.

There are several strengths to this study. First, five different measures of crime were included, two arguably more objective (i.e. police-reported crime, and incivilities measured by audit), two purely subjective (i.e. parents' perceptions of stranger danger and general crime & disorder), and a third type tapping into prior victimization status. To our knowledge, no other study focused on children's physical activity has explored this many crime variables simultaneously. In addition, these measures of crime were more specific than previous studies whereby we separated out parents' perceptions of general crime from perceptions of stranger danger, and further kept all of our measures distinct (vs. combining to create one composite measure). Our approach provides much greater detail of how neighborhood crime may manifest itself than other studies that use a general safety measure (Foster & Giles-Corti, 2008). Furthermore, these measures are clearly not different measures of the single construct of crime, but in fact measure different concepts (e.g. crime vs. abandoned buildings). Thus, it may not only be appropriate to include these measures separately but necessary in order to see how they play a role in health outcomes and behaviors like physical activity.

Second, having three years of cross-street level data for the police-reported crime data not only allowed for more stable estimates, but also allowed us to aggregate to the census block group, which is usually a smaller 'neighborhood' level than police precinct level (Neckerman, et al, 2009) or county (Doyle, et al, 2006) that have been used in prior studies. Third, the current

study also included an even finer-grained neighborhood level metric collected by independent raters by using audit tools on a neighborhood route unique to each participant. These "on the ground" observation of incivilities may be more prescient to parents and ultimately influence their perceptions of crime and safety. Finally, objective measures of physical activity were used, which provides several advantages over self-reported physical activity measures (Sallis & Saelens, 2000). Moreover, unique to this study also is the measure of physical activity by location using parent-reported place logs, with a focus on physical activity occurring within the neighborhood. Again, to our knowledge, an objective, location-specific measure of physical activity has not previously been studied in the context of neighborhood crime.

Limitations of the study also exist. Foremost is the use of cross-sectional data, whereby causality cannot be inferred from any of the significant associations. The generalizability of these findings are also limited; participants were able-bodied children ages 6-11 years old residing in the City of San Diego, a U.S. urban area. Children were also primarily non-Hispanic white and living in moderately to high affluent households. Thus, generalizations beyond these geographic and demographic scopes are cautioned. Our smaller sample size also may have contributed to some of the findings that were not statistically significant.

Future studies that select based on wider income and crime variability may provide additional understanding of how various aspects of crime and safety play a role in children's physical activity and other health outcomes and behaviors. Past research has supported a claim that residents living in lower income neighborhoods have a greater tendency to walk, particularly in their neighborhoods (Bennett et al, 2008; Frank, Engelke, & Schmid, 2003; Handy, Cao, & Mokhtarian, 2006; Ross, 2000; Saelens, Sallis, & Frank, 2003) and that their neighborhoods are

generally more walkable (Handy et al, 2006; Lopez & Hynes, 2006; Loukaitou-Sideris, 2006; Lovasi, Neckerman, Quinn, Weiss, & Rundle, 2009; Neckerman et al, 2009). However, these neighborhoods are also more likely to have higher crime rates and incivilities that may impede their full opportunity to be physically active (Carver et al, 2008; Dannenberg et al, 2003; Diez-Roux et al, 2007; Duncan et al, 2009; Gomez et al, 2004; King et al, 2000; Lopez & Hynes, 2006; Loukaitou-Sideris, 2006; Lovasi et al, 2009; Neckerman et al, 2009; Orleans et al, 2003; Roman et al, 2009; Romero, 2005).

With stronger evidence, next steps beyond this research include working with residents of lower income, higher crime areas for community-based change such as place building and crime prevention through environmental design (CPTED). These have the potential to be helpful solutions to reducing crime and fears and increasing physical activity in the neighborhood. Neighborhood redesign like increasing lighting, cutting back shrubbery, and creating neighborhood ‘places’ for residents to walk to and engage in social interaction are all examples of CPTED. Focusing on place building utilizes several CPTED factors associated with reduced crime and fears and increased neighborhood satisfaction (Cozens, et al, 2005). Other intended outcomes of a neighborhood ‘place’ include creating a sense of community for residents through a gathering space, providing a multitude of activities and destinations that will perpetuate consistent use and physical activity for residents, and providing a framework in which the surrounding community can be built around (Project for Public Spaces, no date). Building neighborhood destinations can foster community pride, active living, and collective efficacy, all of which in turn can provide better health and social outcomes for children and their families.

Acknowledgments

The NIK project was supported by the NIH National Institute of Environmental Health Sciences (NIEHS R01 ES014240). Partial support for this research also came from a *Eunice Kennedy Shriver* National Institute of Child Health and Human Development research infrastructure grant, 5R24HD042828, to the Center for Studies in Demography & Ecology at the University of Washington. Finally, the first author received training funding (NCCR TL1 RR025016) from the National Center for Research Resources (NCRR), a component of the National Institutes of Health (NIH).

The authors would like to thank all of the NIK children and parents for their participation. We would also like to thank Ms. Chris Haley of the San Diego Police Department and her team for granting the request for data and compiling the cross-street level police-reported crime data used in the current study; Dr. Matthew Dunbar, Tim Thomas, and Mike Babb of the University of Washington's Center for Studies in Demography & Ecology for their insight and assistance with GIS and geocoding the San Diego police-reported crimes; and Dr. Robert Crutchfield, Dr. Nicole Bracy, Dr. Amy Hillier, and Dr. Kris Day for their time and insight regarding crime data.

Table 4.1. Factor Analysis & Reliability Coefficients of Items Measuring Perceptions of Crime

Items from parent questionnaire	Factor	
Parents were asked to rate their agreement on potential crime/safety concerns and barriers to children's activity in their neighborhood. All questions below refer to the child's neighborhood unless otherwise specified (e.g. local park)	**Stranger Danger**	**General Crime & Disorder**
I'm afraid of my child being taken or hurt by a stranger on local streets	**0.86**	0.02
I'm afraid of my child being taken or hurt by a stranger in my yard, driveway, or common area	**0.84**	-0.01
I'm afraid of my child being taken or hurt by a stranger in a local park	**0.82**	-0.05
I'm afraid of my child being taken or hurt by a known "bad" person (adult or child) in my neighborhood	**0.70**	0.07
There is nowhere to leave a bike safely	-0.19	**0.76**
My child would have to walk/bike through places to get there that were unsafe	0.09	**0.75**
There are stray dogs	-0.11	**0.74**
It is not safe because of crime (strangers, gangs, drugs)	0.18	**0.71**
There is a high crime rate	0.24	**0.54**
% of variance accounted for	42.60	17.03
Cumulative % of variance	42.60	59.62
Final number of items in scale	4	5
Cronbach's alpha	0.84	0.77

Table 4.2. Characteristics of Children and Their Families and Neighborhoods: Descriptive Statistics

Mean age, years, (SD)		9.2 (1.6)
Sex, n, (%)	Male	71 (49.0)
	Female	74 (51.0)
Race/Ethnicity, n, (%)	Non-Hispanic white	82 (56.6)
	Hispanic	42 (29.0)
	Non-Hispanic non-white	21 (14.5)
Household Income[a], n, (%)	<$50k	30 (21.4)
	$50-100k	54 (38.6)
	>$100k	56 (40.0)
Neighborhood Walkability, n, (%)	Low PAE	68 (46.9)
	High PAE	77 (53.1)
Average Daily MVPA[b], minutes (SD)	Range: 29.6-302.6	135.9 (49.4)
Average Daily Neighborhood MVPA, minutes (SD)	Range: 0-39.2	1.7 (5.8)

Abbreviations: SD, standard deviation; PAE, physical activity environment; MVPA, moderate-to-vigorous physical activity.

[a]n=140 participants whose parents reported household income

[b] n=142 participants who met valid accelerometer wear time criteria

Table 4.3. Descriptive Statistics for Crime Measures & Collective Efficacy

Average police-reported crimes per year for 2007-2009 by census block group, (SD)	Range: 0.3-454.3	87.7 (98.0)
Average total number of neighborhood incivilities, (SD)	Scale: 0-24, Actual Range: 0-12	3.2 (1.8)
Average stranger danger perception, (SD)	Scale: 1-4	2.2 (0.8)
Average general crime & disorder perception, (SD)	Scale: 1-4	1.7 (0.6)
Prior Victimization[a], n, (%)	Yes	39 (27.1)
	No	105 (72.9)
Average collective efficacy perception, (SD)	Scale: 1-5	3.9 (0.7)

Abbreviations: SD, standard deviation

[a]n=144 participants whose parents reported prior victimization status

Table 4.4. Children's Total & Neighborhood Daily Moderate-to-Vigorous Physical Activity (MVPA) by Police-Reported Crime Quartiles

		All children	Neighborhood children	Non-neighborhood children[a]
≤ 25th percentile	Average police-reported crime range	0.3-25.7		
	Average daily MVPA, minutes (SD)	144.8 (52.6)	151.4 (68.8)	141.8 (45.1)
	Average daily neighborhood MVPA, minutes (SD)	3.3 (8.4)	10.9 (12.6)	0
>25th-50th percentile	Average police-reported crime range	26.0-58.3		
	Average daily MVPA, minutes (SD)	131.4 (43.6)	151.5 (66.6)	128.0 (39.2)
	Average daily neighborhood MVPA, minutes (SD)	0.6 (1.9)	4.5 (2.8)	0
>50th-75th percentile	Average police-reported crime range	58.7-103.3		
	Average daily MVPA, minutes (SD)	142.1 (49.5)	134.7 (41.9)	144.6 (52.2)
	Average daily neighborhood MVPA, minutes (SD)	2.2 (7.4)	9.2 (13.2)	0
>75th percentile	Average police-reported crime range	103.7-454.3		
	Average daily MVPA, minutes (SD)	124.9 (50.8)	111.8 (41.8)	126.2 (52.0)
	Average daily neighborhood MVPA, minutes (SD)	0.4 (1.6)	3.7 (4.1)	0

Table 4.4. Children's Total & Neighborhood Daily Moderate-to-Vigorous Physical Activity (MVPA) by Police-Reported Crime Quartiles, continued

Abbreviations: SD, standard deviation; MVPA, moderate-to-vigorous physical activity

[a]=Non-neighborhood children were defined as having no MVPA in their neighborhood and thus have 0 minutes of average daily neighborhood MVPA, regardless of police-reported crime quartile

Table 4.5. Bivariate Correlations Between Neighborhood Crime Measures & Children's Moderate-to-Vigorous Physical Activity (MVPA), Pearson's r (p-value)

	Police-reported crimes	Neighborhood incivilities	Stranger danger perception	General crime & disorder perception	Prior crime victimization	Average daily MVPA (minutes)	Average daily neighborhood MVPA (minutes)
Police-reported crimes	1.00						
Neighborhood incivilities	0.003 (0.97)	1.00					
Stranger danger perception	0.05 (0.53)	0.12 (0.16)	1.00				
General crime & disorder perception	-0.02 (0.82)	0.30 (**0.0002**)	0.30 (**0.0002**)	1.00			
Prior crime victimization	-0.05 (0.53)	0.22 (**0.007**)	0.24 (**0.003**)	0.37 (**<0.0001**)	1.00		
Average daily MVPA (minutes)	-0.13 (0.13)	0.02 (0.80)	-0.03 (0.69)	0.02 (0.85)	0.01 (0.88)	1.00	
Average daily neighborhood MVPA (minutes)	-0.12 (0.15)	-0.07 (0.43)	-0.11 (0.21)	-0.02 (0.83)	-0.08 (0.36)	0.17 (**0.04**)	1.00

Table 4.6. Multilevel Regression Coefficients (95% CI) of Average Daily MVPA (minutes) for Children Living in San Diego

	Model 1: Police-reported crime	Model 2: Police-reported crime + Incivilities	Model 3: Police-reported crime + Incivilities + Parents' Perceptions of Crime	Model 4: Police-reported crime + Incivilities + Parents' Perceptions of Crime + Prior crime victimization	Model 5: Full, Adjusted Model[a]
Police-reported crime by census block group	-0.07 (-0.15, 0.02)	-0.07 (-0.15, 0.02)	-0.07 (-0.15, 0.02)	-0.06 (-0.15, 0.02)	-0.09 (-0.15, -0.03)[b]
Neighborhood incivilities	--	0.68 (-3.75, 5.12)	0.66 (-3.99, 5.31)	0.71 (-3.96, 5.38)	-0.71 (-3.81, 2.40)
Stranger danger perception	--	--	-2.41 (-13.05, 8.23)	-3.40 (-14.25, 7.45)	-1.29 (-7.95, 5.37)
General crime & disorder perception	--	--	1.58 (-12.67, 15.84)	1.33 (-13.50, 16.16)	3.02 (-6.73, 12.77)
Prior crime victimization[c]	--	--	--	1.01 (-18.90, 20.92)	2.74 (-9.62, 15.11)

Abbreviations: CI, confidence interval; MVPA, moderate-to-vigorous physical activity

[a]adjusted for child's age, sex, race/ethnicity, household income, collective efficacy, and neighborhood physical activity environment

[b]significant p=0.005

[c]referent category=no prior victimization

Table 4.7. Multilevel Regression Coefficients (95% CI) of Average Daily Neighborhood MVPA (minutes) for Children Living in San Diego

	Model 1: Police-reported crime	Model 2: Police-reported crime + Incivilities	Model 3: Police-reported crime + Incivilities + Parents' Perceptions of Crime	Model 4: Police-reported crime + Incivilities + Parents' Perceptions of Crime + Prior crime victimization	Model 5: Full, Adjusted Model[a]
Police-reported crime by census block group	-0.01 (-0.02, 0.003)	-0.01 (-0.02, 0.003)	-0.01 (-0.02, 0.003)	-0.01 (-0.02, 0.003)	-0.01 (-0.03, -0.002)[b]
Neighborhood incivilities	--	-0.21 (-0.73, 0.30)	-0.20 (-0.74, 0.34)	-0.18 (-0.72, 0.37)	-0.35 (-0.95, 0.25)
Stranger danger perception	--	--	-0.74 (-1.99, 0.50)	-0.65 (-1.92, 0.61)	-0.65 (-1.88, 0.58)
General crime & disorder perception	--	--	0.28 (-1.39, 1.95)	0.47 (-1.27, 2.21)	0.42 (-1.40, 2.24)
Prior crime victimization[c]	--	--	--	-0.88 (-3.20, 1.43)	-0.73 (-3.02, 1.57)

Abbreviations: CI, confidence interval; MVPA, moderate-to-vigorous physical activity

[a]adjusted for child's age, sex, race/ethnicity, household income, collective efficacy, and neighborhood physical activity environment

[b]significant p=0.02

[c]referent category=no prior victimization

Chapter 5: Associations Between Physical Activity, Cardiorespiratory Fitness and Body Adiposity in Youth and Adults Using Objective Measures

Introduction

Regular physical activity can prevent many chronic illnesses including cardiovascular disease, type 2 diabetes, obesity, and colon cancer with support for other cancers (Brown, et al, 2003; Dubbert, 2002). Physical *inactivity* is "an independent risk factor for chronic disease" with those who are inactive "at a two- to threefold greater risk for premature mortality than their physically active counterparts" (Geller, 2003, p. 1411). The long-term consequences of inactivity are also relevant for children who are consistently inactive (Carver, Timperio, & Crawford, 2008; Committee on Environmental Health, 2009; Duncan, Johnson, Molnar, & Azrael, 2009; Gomez, Johnson, Selva, & Sallis, 2004; Romero, 2005). The cost of inactivity is a significant issue. Colditz estimated that 2.4% of 1995 US healthcare costs were a direct result of sedentary behavior and physical inactivity, approximating $24.3 billion (Colditz, 1999). An additional $70 billion, or 9.4% of healthcare costs were attributed to obesity (Colditz, 1999).

The Centers for Disease Control and Prevention recently published updated physical activity guidelines. Recommendations for adults are 150 minutes a week of moderate activity, combined with muscle-strengthening activities (CDC, 2008). These guidelines remain in line with previous guidelines of the CDC and the American College of Sports Medicine stating 30 minutes of moderate-intensity activity on most days of the week for adults (Blair, LaMonte, & Nichaman, 2004). Youths' recommendations are 60 minutes of physical activity daily (CDC, 2008; Secretary of Health and Human Services & Secretary of Education, 2000). For adults, research suggests health benefits can be gained from consistently engaging in physical activity on a daily basis, with additional evidence suggesting intervals of moderate activity should be at

least 8-10 minutes in length to incur benefits (Dubbert, 2002; CDC, 2008; Blair, LaMonte, & Nichaman, 2004). These short time intervals of physical activity are referred to as ‘bouts.’ The shortest bout length children can be moderately-to-vigorously active to accrue their 60 minute recommendation and resulting health benefits are unknown. Whether or not adults can still gain health benefits from even shorter bouts of activity (i.e. less than 8-10 minutes) that accumulate to the daily recommendations is unknown.

The purpose of this study was to examine the associations between moderate-to-vigorous physical activity (MVPA) and cardiorespiratory fitness and body adiposity. The study also examined whether the relationships between MVPA and cardiorespiratory fitness and body adiposity differed depending on how MVPA is measured, either in 8-10 minute bouts or every minute of MVPA.

Methods

Study Data

The current study utilized National Health and Nutrition Examination Survey (NHANES) 2003-2004 cross-sectional data. NHANES collected demographic and health data from a nationally representative sample of the noninstitutionalized population and included both interviews and physical examinations and testing (CDC, 2009a). NHANES data were collected via home interviews and examinations in mobile examination centers (MEC). Fifteen geographic locations were selected annually, and study staff spent several weeks at each site throughout the given years. For NHANES 2003-2004, 10,122 individuals agreed to participate out of 12,761 recruited originally (Hawkins, et al, 2009). This study was exempt from review by the University of Washington’s institutional review board.

The NHANES sample was collected using a complex, multistage probability design (Troiano, et al, 2008). The current analyses were restricted to individuals who were between the ages of 12-49 years, were ambulatory, and had no major health conditions that would exclude them from undergoing incremental treadmill testing and/or bioelectrical impedance analysis. Full inclusion and exclusion criteria for all objective measures can be found in NHANES 2003-2004 Data Documentation (CDC, 2009b). NHANES 2003-2004 was the only cycle that included all three objective measures of interest (i.e. accelerometer, submaximal incremental treadmill test, and bioelectrical impedance analysis) and thus used for the current study.

The primary exposure of interest, physical activity (as measured by accelerometer) was collected on 7176 participants ages 6 and older who were able to walk (Troiano, et al, 2008). Of those 7176 participants, only 4867 participants were determined to have met valid 'wear time' criteria, defined as 4 or more valid days of 10+ hours (Troiano, et al, 2008). Participants determined to have valid wear time were included in the current sample, with sample reweighting created in order to make this subsample representative of the US population (NCI, 2007). The outcomes of interest were collected on the following sub-samples: cardiorespiratory fitness: 4663 participants ages 12-49 years who were not excluded by specific health conditions and limitations; and body composition: 5329 participants ages 8-49 years. Of these, 2809 participants had estimated VO_2max values and 4159 had percentage body fat estimates. Only participants who had at least four days of valid accelerometer data, estimated VO_2max and percentage body fat were included in the analyses (n=2586).

Study Measures

For all aims, the exposure of interest is physical activity. Physical activity was collected using an Actigraph model 7164 accelerometer. The accelerometer is a small electromechanical

device typically worn around the waist on an elastic band and can be worn under clothing. Participants were asked to wear the device over their right hip for a week and only remove for sleep or water-based activities. Data were captured in ‘counts’ every minute (with higher counts indicative of increased acceleration). These counts in turn are converted into activity intensity by using pre-established cut points. For adults, moderate-intensity activity was defined as 3 METs, equating to a cut-off of 2020 counts, up to vigorous-intensity, equaling or surpassing 6 METs with a cut-off beginning at 5999 counts (Troiano, et al, 2008). Age-based cut points were employed for youth, with moderate-intensity activity defined as 4 METs up to vigorous-intensity, defined as 7 METs or greater (Troiano, et al, 2008). Age-specific count cut points for youth can be found elsewhere (NCI, 2007).

The amount of moderate-to-vigorous physical activity is presented in four ways. Moderate and vigorous physical activity were summed each day and averaged across valid days of wear for each participant with 4 or more days of valid wear time, resulting in average daily moderate-to-vigorous physical activity (MVPA) (in minutes). Average daily MVPA was additionally calculated based on CDC recommendations of accruing MVPA in bouts of at least 8-10 minutes; only MVPA that occurred for at least 8-10 minutes was included here in participants’ average daily MVPA. (See Troiano, et al, 2008, regarding bout criteria). Finally, whether individuals met daily MVPA recommendations of 30 minutes for adults and 60 minutes for youth were categorized as having met recommendations if their average daily MVPA was greater than or equal to 30 minutes for adults and greater than or equal to 60 minutes for youth. This, too, was calculated only using average daily MVPA that accrued in at least 8-10 minutes bouts. All four physical activity measures were used in separate analyses as the exposure of interest.

Cardiorespiratory fitness was measured using a submaximal incremental treadmill test during the examination portion of NHANES. From this, VO_2max (ml/kg/min) is estimated, resulting in a continuous variable (CDC, 2009b).

Body composition was measured indirectly by bioelectrical impedance analysis (BIA), which measures total body water. Electrodes are placed on the right hand and foot of participants and an electrical current is passed through the body to measure the electrical impedance of body tissues. This can be used to assess fat-free mass, and body fat and percentage of body fat can be estimated based off of fat-free mass measurements (CDC, 2009b). Fat-free mass is predicted by adding the mean densities of extracellular fluid and intracellular fluid and their materials multiplied by total body water, assuming total body water is 73.2%. Fat mass is obtained by subtracting fat-free mass from total body weight; fat mass is divided by total body weight and multiplied by 100 to obtain an estimate of % body fat (CDC, 2009b). For ease of interpretation and importance of body fat percentage in health outcomes, % body fat was used in the current study.

Demographic information was collected via self-report during home interviews (CDC, 2009b). Participants were categorized as Non-Hispanic white, Non-Hispanic black, Mexican American, and other. Sex was categorized as male and female. Age of the current sample was restricted to the age criteria to undergo incremental treadmill testing and dichotomized into youth (ages 12-19 years) and adults (ages 20-49 years).

Data Analyses

All analyses were conducted using STATA 10.1 Intercooled (IC) version. Survey methods were employed to account for sample weighting and complex, multistage probability design. Four sets of stratified multiple linear regressions (each set using one of four physical

activity measures) by sex and age categories were conducted for analyses of estimated VO_2max and body adiposity, with physical activity as the exposure of interest and race/ethnicity as a covariate. Significance for all analyses was assessed with a two-sided Wald test with alpha=0.05 and df=15 (Troiano, et al, 2008).

To determine whether or not outcomes differed when average daily MVPA included every minute of MVPA or only accrued in bouts of at least 8-10 minutes, pairs of confidence intervals were compared for each age-sex category's coefficients to examine if they overlapped with one another. If the confidence intervals overlap or one encompasses the other, this provides evidence that they likely are not significantly different from one another. Although this comparison is an approximate test, there is no standard procedure for testing non-nested models, and of the tests that do compare non-nested models, there goal is to compare the fit of the models. This method is a direct and simple approach to see if there are significant differences when MVPA includes all minutes or is restricted to bouts. The same procedure was done comparing whether or not physical activity recommendations were met when every minute of MVPA was included or only MVPA accrued in bouts.

Results

Table 5.1 presents demographics, cardiorespiratory fitness, and body adiposity characteristics and physical activity levels of the study population. The sample is ethnically diverse with 40% non-Hispanic white, 26% African American, and 27% Mexican American. Average cardiorespiratory fitness and body adiposity values in the current study are comparable to national norms of each sex and age group (CDC, 2009c; McKinley Health Center, 2007; Welk & Meredith, 2008).

For boys ages 12-19, all associations between MVPA and cardiorespiratory fitness were significant and in the expected direction except for whether or not daily MVPA recommendations were met in bouts of at least 8-10 minutes ($p=0.31$) (Table 5.2). For example, boys 12-19 years old with one additional minute of MVPA accrued in bouts of at least 8-10 minutes are expected to have an average VO_2max 0.08 ml/kg/min higher ($p<0.001$). For girls ages 12-19 there was only one significant association and that was in the opposite direction than expected with a *lower* VO_2 max in girls who met the daily recommendations. All associations between MVPA and cardiorespiratory fitness were statistically significant and in the expected direction for both men and women ages 20-49 years.

Table 5.3 presents the results of body adiposity measured as percentage of body fat. Both measures of daily MVPA were significantly associated with body adiposity in girls, ages 12-19 years. For example, girls with one minute higher of MVPA accrued in bouts of at least 8-10 minutes had on average 0.1% lower body fat than girls with one minute less ($p<0.001$). There were no significant associations between body adiposity and whether or not girls met daily physical activity recommendations. There were no significant associations between any measures of MVPA and body adiposity for boys, ages 12-19 years.

For women, ages 20-49 years, only MVPA measures that included every minute regardless of bout duration were significantly associated with body adiposity (whereas MVPA accrued in bouts was not statistically significant). For men, all associations between MVPA and body adiposity were statistically significant, regardless if daily MVPA totals included all minutes or only minutes accrued in bouts.

In the current study, there are no statistically significant differences between the two measurements of average daily MVPA in relation to cardiorespiratory fitness and body adiposity.

There are also no significant differences between the two measurements of meeting the daily MVPA recommendations in relation to the two health outcomes. Each pair of confidence intervals overlapped with each other, indicating no significant difference between the measures of MVPA that included every minute or only bouts.

Discussion

The primary finding here is that moderate-to-vigorous physical activity (MVPA) is associated with two critical health-related fitness outcomes, regardless of whether or not MVPA is accrued in bouts of at least 8-10 minutes or if every minute of MVPA is included. This finding provides evidence that encouraging a largely sedentary population to accrue any physical activity at all, even in very short bouts (i.e. less than 8-10 minutes), may provide health benefits. In order to ensure health benefits, though, it is important to be active on a consistent basis and strive for current CDC recommendations (Dubbert, 2002; CDC, 2008; Blair, LaMonte, & Nichaman, 2004). These findings support a study that examined physical activity in adults in relation to weight status (Strath, Holleman, Ronis, Swartz, & Richardson, 2008). A literature review also found associations between physical activity and several health outcomes, regardless if activity was accumulated or continuous but noting insufficient evidence when examining body composition as a health outcome (Murphy, Blair, & Murtagh, 2009). The current study provides evidence that body composition is associated with MVPA when measured both in bouts and including every minute. It should be noted, however, that there is evidence to suggest that if MVPA is accrued in bouts, additional health benefits may be gained because of greater intensity observed during bouts versus activity not accrued in bouts (Strath, et al, 2008).

Physical activity has 3 components: frequency, duration, and intensity. Continuing to provide interventions at several socioecological levels that simply encourage movement on a

regular basis (frequency) over sedentary behavior is a critical first step to reducing health conditions associated with inactivity. In the current sample, approximately 35.7% of participants did not have any MVPA when restricted to bouts, indicating that many are not sufficiently active in line with CDC bout recommendations. Furthermore, as noted in Table 5.1, the prevalence of meeting physical activity recommendations in the current sample was quite low, even when every minute of MVPA was included in the measure, with girls ages 12-19 precipitously lower than the other three sex and age groups. Water-based activities like swimming not captured by the accelerometer are not likely to significantly change the current prevalence estimates, as it was previously estimated that fewer than 5% of the current sample reported swimming for leisure activity (Troiano, et al, 2008). Increasing MVPA length of time in bouts (duration) and intensity are additional critical steps to be addressed once a simple increase in activity at the population-level is achieved.

Past randomized controlled trials have found significant improvements in cardiorespiratory fitness and decreased fat mass following various physical activity prescriptions, indicating that sufficient amounts and intensity of physical activity on a consistent basis have beneficial health outcomes (Duncan, et al, 2005; Slentz, et al, 2004). These studies were conducted with adults, and Slentz and colleagues used skin folds to estimate fat mass, so the current study adds to this by including children in the sample, and a different objective measure of body adiposity, providing a another perspective of total percentage of body fat. Furthermore, the current study used a large nationally representative sample of individuals, ages 12-49 years. Other studies used NHANES accelerometer data to examine the relationship between MVPA and children's weight status (Mark & Janssen 2009; Belcher, et al, 2010). Mark and Janssen's findings suggest that small bout recommendations for children may in fact be appropriate, as

MVPA accrued in bouts were associated with lower weight status independent of total MVPA accrued (Mark & Janssen 2009). Belcher and colleagues found an inverse relationship between physical activity and weight status noting one limitation was the use of weight status in place of body adiposity (Belcher, et al, 2010). The current study provides additional evidence of MVPA's association with other health outcomes, body adiposity included, that are relevant to youth both in the short- and long-term regardless of how MVPA is accrued.

All relationships found to be significant between physical activity and the two health outcomes are in the expected direction with increased physical activity associated with increased cardiorespiratory fitness and decreased body adiposity, with one exception of girls ages 12-19 who met physical activity recommendations in bouts of at least 8-10 minutes with lower average VO_2max levels than girls who did not meet recommendations. In the current study, only 0.8% of girls were found to have met the daily recommendations in bouts of at least 8-10 minutes. This limited comparison group is likely to have contributed to these findings. Because this data is cross-sectional, it is possible that young girls who are less fit may have overachieved while wearing the accelerometer (i.e. Hawthorne Effect). It is also possible that correcting for the number of tests, this finding may merely be random variation rather than a true association.

One of this study's major strengths is the use of objective measures for physical activity, cardiorespiratory fitness, and body adiposity. The particular focus and advancement is the objective measurement of physical activity using accelerometers on a large, national database. Using objective measures avoids issues that come from subjective self-reports (Sallis & Saelens, 2000). Accelerometers provide not only the total amount of free-living physical activity but also the frequency, duration, and intensity of it (Freedson & Miller, 2000; Trost, McIver & Pate, 2005). Additionally, the current study examined the association between physical activity and

two primary health outcomes: cardiorespiratory fitness and body composition. These health outcomes are critical components of health-related fitness, and they are the primary components indicated for an individual's overall health, cardiovascular health, and physical performance (Dishman, Washburn & Heath, 2004).

The limitations of this study include its cross-sectional design, whereby causality cannot be determined between the relationships of interest. In addition, generalizability of the findings are limited in scope to those who are ambulatory and meet certain age and health requirements—indicative of a younger and healthier subpopulation. Generalizations cannot be made to those who are older and/or who have more significant health issues. Comparing confidence intervals to determine if all minutes of physical activity or only bouts make a difference in health outcomes is an approximate test, so some caution is warranted in the conclusions. Unfortunately, without a standard analysis to compare outcomes when the exposure of interest is measured in two ways (here, physical activity), a solution to this limitation is not readily available.

Although many of the relationships here between physical activity and cardiorespiratory fitness and body adiposity are statistically significant, whether they are clinically significant is unclear. The current study examines daily MVPA levels and recommendations; future studies that examine the association between weekly MVPA levels and recommendations and the same health outcomes examined in this study may potentially find stronger and clinically relevant associations. Finally, although bioelectrical impedance analysis is a recognized tool for measuring body composition, it does so indirectly. This is a limitation as its results are subject to error based on participant hydration status. Future validation research comparing bioelectrical impedance analysis to dual-energy x-ray absorptiometry (DXA) is warranted. Should results be

similar, bioelectrical impedance analysis could be an appropriate cost-effective alternative for measuring body composition.

Acknowledgments

The author would like to thank Chuck Maynard, PhD, for his assistance in putting the NHANES 2003-2004 accelerometer data into a useable format, Allen Cheadle, PhD, David Grembowski, PhD, Peggy Hannon, PhD, and Brian Saelens, PhD, for reviewing and providing feedback on the manuscript, Gary Chan, PhD, for reviewing the manuscript and statistical consultation, and Nicholas Smith, PhD, for reviewing the manuscript. The author would also like to thank the anonymous reviewers who provided additional feedback on the original manuscript. No funding was received for the preparation of this article, and the author has no stated conflicts of interest.

Table 5.1. Demographic Characteristics of Study Sample (SE)

		All	Girls Ages 12-19 years	Boys Ages 12-19 years	Women Ages 20-49 years	Men Ages 20-49 years
Total, n (%)		2586 (100)	570 (22)	611 (23.6)	717 (27.7)	688 (26.6)
Mean age, years		26.2 (0.4)	15.3 (0.1)	15.2 (0.1)	35 (0.5)	35.1 (0.5)
Race/Ethnicity, %	Non-Hispanic white	40.1	26.5	25.7	52.6	52.1
	Non-Hispanic black	26.4	34.1	38.2	19.1	17.9
	Mexican American	26.7	34.8	31.6	20.4	22.7
	Other race	6.3	4.7	4.5	7.9	7.3
Avg VO2max, ml/kg/min		40.6 (0.3)	38 (0.5)	45.1 (0.5)	35.6 (0.5)	42.2 (0.6)
Avg % body fat		29.8 (0.3)	36.2 (0.3)	22.1 (0.4)	38.6 (0.4)	23.6 (0.4)
Avg Daily MVPA, min (8-10 min bouts)		10.4 (0.4)	6.9 (0.5)	19.3 (1.0)	6.2 (0.5)	10.2 (0.7)
Avg Daily MVPA, min (every min)		32.2 (0.7)	24 (1.0)	45.3 (1.5)	20.6 (0.7)	40.1 (1.3)
Met MVPA recommendation (8-10 min bouts), %		5.1	0.8	5.8	4.1	8.9
Met MVPA recommendation (every min), %		28.8	5.1	27.3	21.4	57.7

Abbreviations: SE, standard error; MVPA, moderate-to-vigorous physical activity.

Table 5.2. Regression Coefficients (95% CI) Cardiorespiratory Fitness (ml/kg/min)

	Girls Ages 12-19 years	Boys Ages 12-19 years	Women Ages 20-49 years	Men Ages 20-49 years
Daily MVPA, min (8-10 min bouts)[a]	0.07 (0, 0.15) $p = 0.07$	0.08 (0.04, 0.12) $p < 0.001$	0.15 (0.04, 0.26) $p = 0.005$	0.09 (0.03, 0.16) $p = 0.003$
Daily MVPA, min (every min)[a]	0.04 (-0.01, 0.08) $p = 0.09$	0.07 (0.04, 0.10) $p < 0.001$	0.11 (0.04, 0.17) $p = 0.001$	0.05 (0.02, 0.08) $p = 0.003$
Met MVPA recommendation (8-10 min bouts)[a]	-4.41 (-8.24, -0.58) $p = 0.02$	1.36 (-1.26, 3.97) $p = 0.31$	6.35 (0.36, 12.34) $p = 0.04$	3.92 (1.13, 6.71) $p = 0.006$
Met MVPA recommendation (every min)[a]	0.26 (-2.67, 3.19) $p = 0.86$	4.49 (2.69, 6.30) $p < 0.001$	2.51 (0.23, 4.78) $p = 0.03$	2.84 (0.68, 5.00) $p = 0.01$

Abbreviations: CI, confidence interval; MVPA, moderate-to-vigorous physical activity.
[a] Accounting for Race/Ethnicity

Table 5.3. Regression Coefficients (95% CI) Body Adiposity (% body fat)

	Girls Ages 12-19 years	Boys Ages 12-19 years	Women Ages 20-49 years	Men Ages 20-49 years
Daily MVPA, min (8-10 min bouts)[a]	-0.10 (-0.16, -0.05) $p < 0.001$	0 (-0.03, 0.04) $p = 0.92$	-0.08 (-0.16, 0) $p = 0.05$	-0.06 (-0.10, -0.02) $p = 0.007$
Daily MVPA, min (every min)[a]	-0.05 (-0.08, -0.01) $p = 0.005$	-0.01 (-0.04, 0.02) $p = 0.54$	-0.06 (-0.10, -0.01) $p = 0.02$	-0.06 (-0.08, -0.03) $p < 0.001$
Met MVPA recommendation (8-10 min bouts)[a]	-2.57 (-6.93, 1.79) $p = 0.25$	0.51 (-2.11, 3.14) $p = 0.70$	-1.80 (-4.01, 0.40) $p = 0.11$	-2.11 (-4.03, -0.20) $p = 0.03$
Met MVPA recommendation (every min)[a]	0.23 (-2.16, 2.61) $p = 0.85$	-0.41 (-2.15, 1.33) $p = 0.65$	-2.43 (-3.84, -1.01) $p = 0.001$	-3.14 (-4.52, -1.77) $p < 0.001$

Abbreviations: CI, confidence interval; MVPA, moderate-to-vigorous physical activity.
[a] Accounting for Race/Ethnicity

Chapter 6: Conclusion

Summary

There are far-reaching physical, psychological, and social benefits to meeting physical activity recommendations across all ages. Despite these known benefits, most Americans do not meet these recommendations (Troiano, et al, 2008). Resulting consequences are becoming more prevalent at the population level, most notably rising trends in obesity. Childhood obesity is particularly concerning for public health officials. This is because not only is it associated with childhood health consequences (Freedman, et al, 2007; Must & Strauss, 1999), but it is predictive of obesity and health conditions in adulthood, too (Freedman, et al, 2007; Thompson, et al, 2007; Tirosh, et al, 2011). Policy and interventions aimed at increasing physical activity levels at an early age are warranted to combat these detrimental health outcomes.

It is recognized that obesity and other health consequences are complex, and physical activity is only one of several influences on health. Nonetheless, physical activity is a critical health behavior that is modifiable and has the potential to impact these health outcomes. This dissertation examined several individual, family, and environmental factors that were potentially related to children's physical activity (how much and where) and important health services outcomes (i.e. health care use). It also examined the relationship between physical activity and two physical fitness-related health outcomes in a nationally representative sample of adolescents and adults. Collectively, this dissertation demonstrated that meeting physical activity recommendations is significantly related to positive health outcomes for children, adolescents, and adults, supporting previous findings (see Physical Activity Guidelines Advisory Committee, 2008, for a review). Furthermore, this dissertation also demonstrated that not only is a child's

neighborhood a valid location for physical activity policy and interventions but also that neighborhood crime may be a specific and worthwhile barrier to target.

Findings & Implications

In Chapter 5 we found that meeting MVPA recommendations is significantly associated with lower body adiposity and higher cardiorespiratory fitness in both adolescents and adults. This provides further support for previous findings that physical activity has far-reaching benefits in childhood through adulthood as previously demonstrated (see Physical Activity Guidelines Advisory Committee, 2008, for a review). We also found preliminary evidence suggesting that accruing physical activity in bouts less than the recommended 8-10 minutes for adults may still be associated with health benefits. Encouraging a largely sedentary population to accrue any physical activity at all, even in very short bouts (i.e. less than 8-10 minutes), may be a legitimate focus for population-based interventions. One of the most cost-effective physical activity interventions to date is signs promoting the use of stairs (Wu, Cohen, Shi, Pearson, & Sturm, 2011). Typically, taking the stairs is an activity that is completed in less time than the bout recommendation of 8-10 minutes. Why people choose to take elevators over stairs with these prompts present is not definitively clear, but it is possible that some may think there is not much to be gained in the way of health for the couple of minutes of activity they would expend. By adding additional information that the few extra minutes of physical activity accrued from taking the stairs has a health impact, perhaps these signs could be even more effective in increasing the use of stairs for some individuals. Prompts such as these have very small effects of increasing overall physical activity levels at an individual level (Wu, et al, 2011), but by simply encouraging movement on a regular basis over sedentary behavior is a critical first step to reducing health conditions associated with inactivity. Additionally, these small individual

increases in physical activity can quickly add up to a larger population-level change in physical activity levels. This theory has been championed in public health for population prevention strategies of several chronic conditions by shifting societal norms, even a little, to make a larger societal health impact (Rose, 1985). Prompts that promote immediate opportunities to be active are simple and effective ways of incorporating physical activity into the day that in turn can begin the process of creating a more consistent physical activity habit.

We found that physical inactivity and higher child weight status are related to greater child health conditions but not related to greater health care use or school absence after accounting for health conditions in Chapter 2. To our knowledge, this is the first study to examine children's physical activity and how it relates prospectively to children's health services use and school absences. Although physical activity is both a primary and secondary prevention tool for children's weight status and other health conditions, it may be that the benefit of physical activity in the form of less health care use does not manifest until several decades later and was therefore not captured in our 2-year timeframe (Must & Strauss, 1999). Future research that takes a life-course perspective may help clarify the role of physical activity in health and health services outcomes. With this perspective, it is recommended that physical activity levels and these outcomes are followed from very early childhood well into adulthood. A life-course perspective champions health and wellbeing in childhood, because it is recognized that a healthy childhood can improve population health by preventing precursors of adult health conditions (Forrest & Riley, 2004). For example, some have found that higher levels of physical activity in 4 year olds was significantly predictive of lower body fat percentage at age 11 relative to less active children (Moore, et al, 2003). Others have found a link between adolescent overweight status and adult coronary heart disease even after controlling for adult overweight status (Tirosh,

et al, 2011). To understand the connection between these findings of physical activity predicting weight/body composition and weight predicting health conditions as individuals mature, expanding these types of longitudinal studies by starting earlier (i.e. preschool age), having extensive follow-up, and including health behaviors and health services use measures would enhance the research. In addition, incorporating other behaviors not captured in our study, specifically eating practices and amount of sedentary time (e.g. ‘screen time’), may further elucidate specific childhood health practices related to children’s weight, health conditions and health care use from their childhood through adulthood.

Our findings in Chapter 5 support the pathway posited in Figure 1.1 between cardiorespiratory fitness and body adiposity (Andersen’s *needs* that may require health care) and the *health behavior* physical activity (Andersen, 1995). We also found support for relationships between two other *needs* (weight status and health conditions) and physical activity in Chapter 2. We did not find support for all pathways of Figure 1.1 tested in Chapter 2, however. Although we found a predictive relationship between income (an *enabling resource*) and health conditions (health care *need*) on health care visits, we did not find support for other *predisposing factors*, health care *needs*, and *health behaviors* thought to play a role in health care visits, including child weight status and physical activity. We also did not find support for pathways tested between these same factors and school absences. It may be that some of the factors tested in these models are not as impactful in young children (age 6-11) as they are in adults and even adolescents (Ryan, et al, 2011). It may also be that, as previously noted, childhood factors such as weight status and physical activity do impact health care use, but their impact does not manifest until adolescence and onward. Thus, a life-course perspective could be considered in adapting Andersen’s Model of Behavioral Model of Health Services Use (Andersen, 1995).

Finally, although school absences may be an additional indicator of child health, it may not serve as a proxy for other health services outcomes like health care use. Thus, school absences should continue to be studied for its health and social impact on both children and their parents (e.g. falling behind in school, parents taking time off of work), but future studies should still include more traditional health service outcomes, too.

In Chapter 3, we used a novel approach to examine where children are active by integrating accelerometer data with prospective parent logging of child whereabouts by time. These findings added additional place categories beyond those previously studied (Corder, et al, 2011; Grow, et al, 2008; Mackett, et al, 2005; Mackett & Paskins, 2008) and included locations that were not inherently physical activity-based (e.g. food eateries, service locations). We found that 6-11 year old children spend most of their time at home and school, but they spend a relatively low percentage of their time in these places engaged in moderate-to-vigorous physical activity (MVPA). In contrast, children spend little time in their own neighborhood, but almost half of the time there is spent engaged in MVPA, and the neighborhood was the most active location relative to all other locations studied. Moreover, we found that children who spent any time in their neighborhood had significantly higher amounts of overall MVPA than children who spent no time in their neighborhood. Further examination revealed that activity in the neighborhood likely was not substituting for MVPA in other places but in fact added to neighborhood children’s overall MVPA. These findings provide evidence for future interventions that aim to increase time spent outside in the neighborhood. Specifically, with the high percentage of time spent in the home, interventions that increase the appeal of play in the neighborhood, which is just steps outside the home, may shift children outside and provide the opportunity to increase children’s physical activity and unstructured play. Policy and research

focused on creating policies and interventions that increase children's time spent in the neighborhood may be associated with higher overall levels of neighborhood MVPA and average daily MVPA. However, we did not find any statistically significant associations between demographic, parent perception, and neighborhood factors as they relate to children accruing any MVPA in the neighborhood. This makes it challenging to know what specific types of interventions would increase neighborhood MVPA. Future qualitative and community-based participatory research, in addition to perhaps more fine-grained and sensitive measures of neighborhood factors, may provide insight into factors deemed most relevant by parents that will increase their children's physical activity in the neighborhood.

Chapter 4 provided a more in-depth examination of neighborhood crime and personal safety factors in relation to children's physical activity. Unique to this study and that of Chapter 3 is the measure of physical activity by location using parent-reported place logs, with a focus on physical activity occurring within the neighborhood. To our knowledge, an objective, location-specific measure of physical activity has not previously been studied in the context of neighborhood crime. In qualitative research, these crime-related issues are often cited by parents as factors in their decision to allow their children to be out and independent in their neighborhood (Valentine & McKendrick, 1997; Veitch, Bagley, Ball, & Salmon, 2006; Weir, Etelson, & Brand, 2006). We examined the relationship between five different crime measures and children's total and neighborhood physical activity in Chapter 4. Of these five crime measures, higher police-reported crimes in the neighborhood, after accounting for other crime variables and demographics, was associated with less child overall moderate-to-vigorous physical activity (MVPA) and specifically lower child MVPA within the neighborhood. Children living in neighborhoods that were in the highest quartile of police-reported crime had the lowest

overall MVPA, and ‘neighborhood’ children had the lowest overall levels of MVPA compared to all others (about 112 minutes for ‘neighborhood’ children living in the highest police-reported crime quartile neighborhoods vs. approximately 126 minutes for ‘non-neighborhood’ children living in the same quartile). In contrast, children living in neighborhoods that were in the lowest quartile of police-reported crime had the highest levels of physical activity, and ‘neighborhood’ children living in this quartile had the highest overall and highest neighborhood MVPA amongst all the other groups, approximately 151 minutes and 11 minutes, respectively.

Future policy and interventions that target high crime neighborhoods using crime prevention through environmental design (CPTED) may be logical and effective possibilities for addressing high crime and low physical activity (Day, Anderson, Powe, McMillan, & Winn, 2007). CPTED is the use of built environment design and urban planning to reduce crime, the fear of crime, and improve quality of life for residents (Cozens, Saville, & Hillier, 2005). Neighborhood redesign like increasing lighting, cutting back shrubbery, and creating neighborhood ‘places’ for residents to walk to and engage in social interaction are all examples of CPTED. Although we did not find a statistically significant relationship between children’s MVPA and neighborhood incivilities or parents’ perceptions of crime, we did find that the presence of incivilities was related to greater parent perceptions of crime and greater likelihood of prior victimization. While addressing our primary finding between higher police-reported crime and lower overall MVPA and child MVPA within the neighborhood, CPTED revitalization projects have potential added benefit to assuage these additional concerns of incivilities, perceptions of crime and prior victimization through neighborhood clean-ups and place building that can foster community pride and cohesion. Focusing on place building utilizes several CPTED factors associated with reduced crime and fears and increased neighborhood

satisfaction (Cozens, et al, 2005). Other intended outcomes of a neighborhood 'place' include creating a sense of community for residents through a gathering space, providing a multitude of activities and destinations that will perpetuate consistent use and physical activity for residents, and providing a framework in which the surrounding community can be built around (Project for Public Spaces, no date). Collaboration between public health officials, urban planners, criminologists, and most importantly neighborhood residents are essential for the implementation and sustainability of projects such as these.

We tested several pathways of Figure 1.2 to determine children's physical activity levels and where they accrued their activity. All pathways tested in Chapters 3 and 4 that were significant were in the expected direction (e.g. high physical activity environment, higher neighborhood physical activity, and higher neighborhood crime, lower physical activity in Chapter 4), but not all pathways were significant. Additional objective neighborhood environment measures that we did not include in our studies (e.g. presence of transportation options) should be included alongside the large number of subjective measures that we included in Chapter 3. This could provide a more in-depth comparison between objective vs. subjective measures of other neighborhood factors that may influence children's physical activity, particularly in their neighborhood. Furthermore, testing potential mediation pathways between more objective neighborhood factors and parents' perceptions of these factors may shed additional light into the relationship between the neighborhood environment and how it affects children's physical activity by location.

In summary, this dissertation provides evidence for future research and interventions that operate on several levels of a socioecological model and encourage a life-course perspective.

Furthermore, these recommendations promote collaboration across health and several other disciplines with additional consideration for neighborhood residents' input.

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Appendix: Place Category Descriptions

Place Category	Sub-Category	Description
1. Home		The home address previously identified during the neighborhood selection process stands alone here, with all other parents' and guardians' home that are separate listed under *others' homes*. If parent lists 'front yard' or 'backyard' in place log, this is also considered *home*.
2. School		The child's school in which they are currently enrolled also stands alone here (even if child wore the accelerometer during school vacations). If a child is home schooled and attends any home school co-op, this would be considered *school*.
3. Neighborhood		This category includes only entries that specifically say 'neighborhood' with no specific address noted, as per place log instructions to parents. All place log entries with no specific location or address *and do not specify 'neighborhood'* (e.g. bike riding, walked dog, trick or treating) are also included here. Rationale: Place log entries with no specific address fall under the realm of 'neighborhood' (as this was the only entry whereby parents were permitted to provide no address, as by definition being out in

Place Category	Sub-Category	Description
		the neighborhood does not have a specific address). If any of these entries occurred at a specific place, parents would indicate with an address.
4. Others' Homes		This category includes relatives (including separate parent/guardian households not identified as the primary address), friends', neighbors', and babysitter's homes.
5. Other Schools		This includes schools that are not identified as the child's school in which they are enrolled. This category also includes colleges and universities.
6. Public, Outdoor Parks & Recreation Facilities		For parks, this includes all parks, general and more specific (e.g. skate park, dog park), and any other park features (e.g. basketball court, tennis court, sports fields). Other outdoor recreational locations (including national/state parks, lakes, beaches, ski/snow locations, trails, conservatories, and gardens) are included here, too. Outdoor public pools and water-play areas (likely a park feature) are included.
7. Public, Indoor Recreation Facilities		This includes community centers, YMCA, and Boys & Girls Clubs. Indoor public pools and facilities are also included.

Place Category	Sub-Category	Description
8. Private Recreation Facilities		This category is comprised of leisure places of activity (e.g. bowling alley, golf course), gyms (e.g. 24 Hour Fitness®), martial arts, dance studios, and other private activity lessons/locations, private clubs that are social but more likely geared toward physical activity (e.g. tennis and beach clubs), and water parks.
9. Service Locations		This category includes: libraries, post offices, hospitals, military bases (but *excludes* commissaries), banks/credit unions, hotels, cemeteries/mortuaries, transportation centers or stops (e.g. train, bus, airport, ferry terminal, marina), movie theatres, religious organizations, international schools, language schools, religious schools, car washes, veterinary/humane societies, video rental stores, recycle/waste centers, nursing homes, and government agencies. Other locations encompassed here are art, music, drama, therapeutic (e.g. speech therapy) lesson locations, tutoring, Brownies & Cub Scouts, 4-H Club, before/after care & daycare centers. Other errand locations like going to a parent or other person's work, appointments such as dental or orthodontic

Place Category	Sub-Category	Description
		exams, eye or doctor's appointment, haircut, etc. are included in this category. Any reports of 'waiting' (e.g. waiting in car, waiting for brother) are also included here. Cultural centers and special outings (e.g. museums, music halls, stadiums like Safeco Field or Petco Field, amusement parks, zoos, aquariums, parades, fairs, holiday-based outings like tree lot and pumpkin patch) are listed here. Other private social clubs that are not geared for physical activity (e.g. yacht and boat clubs) are included here.
10. Nondescript Geographic Locations		Includes daytrips and large geographical locations without descriptive types of places (and/or specific addresses outside of the participant's neighborhood). Examples of this include 'Downtown Seattle,' where it is unknown where specifically participants went.
11. Shopping	Non-Food Shopping	This category includes all non-food shopping (e.g. clothing stores), shopping centers and malls, dollar stores, automotive stores, drugstores/pharmacies, electronics stores, big box stores (e.g. Wal-Mart®, Target®), hardware stores, and waterfront

Place Category	Sub-Category	Description
		centers like an embarcadero.
	Convenience Stores	This includes 7-11® and all other convenience stores previously identified for the purpose of NEMS-S food enumeration (see Glanz, et al, 2007 for further information).
	Markets & Produce Stores	This includes public markets, farmers' markets and any other locations previously identified for the purpose of NEMS-S food enumeration (see Glanz, et al, 2007 for further information).
	Grocery Stores	All grocery stores and supermarkets are included here, as well any others previously identified for the purpose of NEMS-S food enumeration. Large club stores (e.g. Costco®, Sam's Club®) are included here since they are primarily food shopping-focused. Armed forces commissaries and grocery store outlets are included here, too. (See Glanz, et al, 2007 for further information).
12. Food Eateries	Fast Food Restaurants	All fast food chains and other locations identified for the purpose of NEMS-R food enumeration (see Saelens, et al, 2007 for further information).
	Sit-Down Restaurants	Local and chain sit-down restaurants are included here, as defined and identified for

Place Category	Sub-Category	Description
		the purpose of NEMS-R food enumeration. Buffets and Fast Casual Restaurants noted as separate categories in NEMS-R food enumeration are included here. (See Saelens al, 2007 for further information).
	Specialty Food Shops	Bakery, donuts, ice cream, cookies, and juice shops, specialty markets, coffee shops, bagel shops (both independent and chain locations) identified for the purpose of NEMS-S food enumeration are included here (see Glanz, et al, 2007 for further information).

VITA

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