

Predictors of Physical Activity and Substance Use in U.S. Adolescents

by

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Chapter 1

Introduction

Physical activity has declined over the last several decades, with significant changes observed in childhood and adolescent populations (CDC, 2005). The lack of physical activity coupled with other factors has been credited with the shift towards obesity in the United States. Nearly 80% of all children and adolescents do not meet the daily recommendations for physical activity set forth by the Department of Health and Human Services (DHHS) and the American College of Sports Medicine (2002)(Eaton et al., 2006). In fact, when compared to other industrialized countries, the United States is more obese and reports less physical activity in all age groups (Allison, Adlaf, Dwyer, Lysy, & Irving, 2007).

Preventable diseases such as diabetes, hypertension, and coronary artery disease have been associated with the decline in physical activity and the rise in obesity (Eaton et al., 2006; Hardman, 2001; USDHHS, 1999). The United States Centers for Disease Control and Prevention (CDC) and the DHHS recommend research and interventions aimed at increasing physical activity in an effort to decrease the proportion of the population that is obese and decrease the incidence of related chronic diseases. While the benefits of physical activity and weight reduction are obvious, there are other benefits that have not been as well explored.

There is limited research that examines the potential link between physical activity, risk and protective factors, and health risk and health promoting behaviors in adolescents (Adams & White, 2003; Blanchard et al., 2003; Boyd & Hrycaiko, 1997; Dishman et al., 2004; Jamner, Spruijt-Metz, Bassin, & Cooper, 2004; Neumark-Sztainer, Story, Hannan, & Rex, 2003; Patrick et al., 2001; J. F. Sallis et al., 2000; Stone, McKenzie, Welk, & Booth, 1998).

Based on previous research it is evident that much is known but little is understood related to physical activity in adolescents. While studies agree that physical activity declines with age, reasons for this decline are not well understood (Eaton et al., 2006; Pate, Dowda, O'Neill, & Ward, 2007).

Developmental changes and transitions in this age group, competing demands from the school and social spheres, and poor access to facilities may play a role in this decline. While there is decreased physical activity among all adolescents, girls, African Americans, and Hispanics report less physical activity and more sedentary activity than Caucasian subgroups. Reasons for these differences are related to lack of access to exercise facilities or parks, cultural differences in body image and ethnic identity, and reported lack of enjoyment of physical activity (Eakin et al., 2005; Eaton et al., 2006; Gordon-Larsen, Adair, & Popkin, 2002; Taylor et al., 1999; Whaley & Francis, 2006).

Past physical activity research has focused primarily on barriers to physical activity and behavioral modification via individualized and group interventions. There has been limited exploration of physical activity as a protective factor for risky behaviors such as tobacco and substance use. The

relationship between physical activity and risk and protective factors has not been well studied. It is not clear if physical activity is associated with specific risk or protective factors or health risk behavior. Furthermore, physical activity is rarely considered as a protective factor in relation to health risk behaviors.

Despite the growing interest in physical activity research, the relationship between risk and protective factors and physical activity has not been thoroughly investigated. It is unclear which risk factors are most predictive of physical inactivity and which protective factors are most predictive of physical activity. Furthermore, even fewer studies have examined physical activity as a protective factor or a moderator for risky health behaviors such as substance use (Arthur, Hawkins, Pollard, Catalano, & Bagioni Jr., 2002; Jessor, 1991; Nelson & Gordon-Larsen, 2006; Pate, Heath, Dowda, & Trost, 1996; Werch et al., 2003).

The adolescent's perception of built and personal environment is rarely mentioned in physical activity studies, even though it may be a barrier, risk, or protective factor. Little research has explored the perceived or personal environment of adolescents in relation to their reported physical activity (Babey, Hastert, & Brown, 2007; J. Sallis et al., 2003). In addition, studies have failed to adequately study the relationship of the physical and social environment to physical activity specific to adolescents. Not only do these variables have the potential to act as risk or protective factors in adolescents, they have the potential to be further unique within subgroups and require additional research due to the differences and uniqueness of each culture and gender.

While it is well known that physical activity rates are declining, the circumstances surrounding this decline are not well understood. A great deal of research has identified specific barriers and correlates of physical activity and risk and protective factors for healthy and risky behaviors, but few studies have linked the two concepts. This research aims to identify and examine risk and protective factors that are predictive of physical activity and substance use and further explore the moderating effect of physical activity on risk and protective factors. The Ecological Model of Adolescent Health Risk Behaviors is the guiding framework for this research.

The purpose of these studies is to examine three separate, but related, research questions that explore the relationship of physical activity to specific risk and protective factors and health risk and promotion behaviors in adolescents. The first study examines the relationship between risk and protective factors, tobacco use, and physical activity. Alternatively, the second study will examine physical activity as a predictor of alcohol use. Finally, the third study will explore the adolescent's perceived and personal environment as a set of risk factors of physical inactivity and protective factors of physical activity and evaluate the identified predictors over time.

Ecological Model of Adolescent Health Risk Behaviors

The guiding framework for all three studies is the Ecological Model of Adolescent Health Risk Behaviors. Originally described by Jessor (1977) as Problem Behavior Theory, and influenced by Bronfenbrenner's Ecological Systems Model (Bronfenbrenner, 1979), the current Ecological Model has

evolved to include six domains of influence over adolescent behavior (Blum, McNeely, & Nonnemaker, 2001). This revised model (Figure 1) proposes that the macro-level environment, social context (including the peer context), school context, family context, and individual context interact with each other to influence adolescent behavior and produce either health risk behaviors or youth health outcomes. Within each domain risk and protective factors interact and ultimately influence behavior.

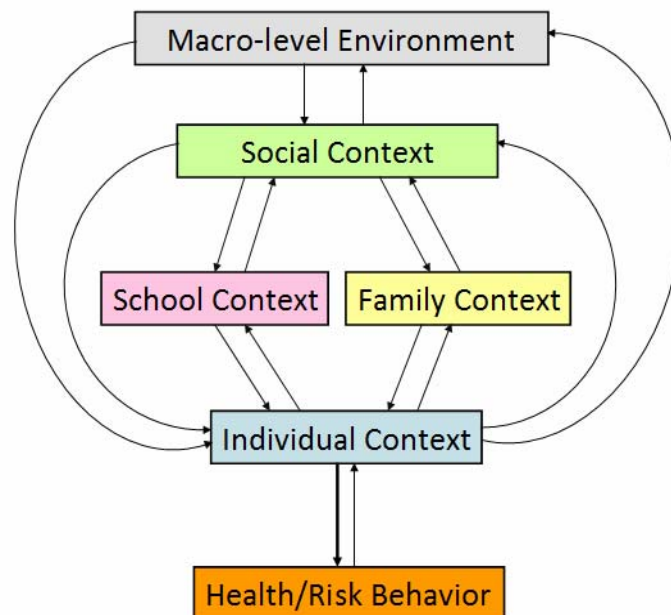


Figure 1- Ecological Model of Adolescent Health and Risk Behavior

The overall goal of the Ecological Model is to incorporate the environment and time into the model as an influence on risk and protective factors and, ultimately, adolescent behavior. Specifically, the domains or contexts that have the greatest potential to influence the adolescent on the individual level, the peer, school, and family contexts, are looked at through a broader scope utilizing the immediate social community and the macro-level community. These domains

provide the context for understanding adolescent risk and protective factors. The social context, which includes the peer context, exposure to violent media, and access to substances, has a direct effect on the school and family contexts, as well as on the individual domain and the macro-level environment. The macro-level environment, which consists of the political climate and historical events, only directly effects the immediate social environment and the individual domain.

Interestingly, the authors state that individuals do not have the power in this model to have an impact or influence their environment. However, a direct path from the level of the individual is drawn to the immediate social environment and the macro-level environment indicating that individuals can, in fact, influence or have an impact on their environment. While the strength of the individual impact on environment would be difficult to determine, it is perhaps more important to consider the individual's perceived impact on the environment as an element that may influence or alter risk behaviors or health outcomes. In other theories, such as Social Cognitive Theory and Bronfenbrenner's Ecological Systems Theory, it is quite possible for adolescents to have some impact not only on their immediate social environment, but influence the macro-level environment as well and thus should not be discounted when examining risk and protective factors.

Furthermore, this dynamic model allows for the environment to influence risk and health outcomes (through the level of the individual) which, in turn, have the potential to become risk or protective factors themselves at a later point in time. The outcome or observed risk or health behavior is not the end of the

model. Once a health or risk outcome is achieved, it re-enters back into the model at the level of the individual to act as a risk or protective factor for future development of behaviors and outcomes. For example, a set of protective factors may lead to a youth health outcome of positive family relationships. Once this outcome is achieved, it re-enters the model as a protective factor for future behaviors and outcomes.

The Ecological Model posits three general propositions that explain the mechanisms of action of protective factors on adolescent behavior. Primarily, the authors note that protective factors and processes are able to extend beyond multiple contexts (Blum et al., 2001). That is to say that the macro-level protective processes condition or influence the protective mechanisms at the school, social, peer, family, and individual levels. Secondly, these protective mechanisms and processes change within each context and may be interpreted differently in each domain. For example, a protective factor in the context of the school may not be a protective factor when examined within the family domain. Finally, the protective processes and mechanisms differ related to the risk process or mechanism. Thus, different groups of risk factors or influences may produce a negative outcome despite the protective mechanisms in place. A protective factor may buffer one risk factor while having no effect, or the opposite effect, on another. Peer influence provides a good example. Despite protective mechanisms within the family and school against substance use, peers who use substances have great influence over adolescents and may, in fact, produce a substance use outcome.

The macro-level environment has a direct effect on the immediate social environment or context and the individual domain. The political climate, governmental policies and procedures, and the community resources influence adolescents' risk and protective factors and, ultimately, risk and health outcomes. The social context itself has more power to influence adolescent behavior by having a direct effect on the school, family, and individual contexts, as well as a reciprocal effect on the macro-level environment. The school and family domains have direct influence on the individual domain. As may be expected, the individual domain has the potential for weak effects on the school, family, and social domains. The risk and protective factors in all domains interact to influence the individual. Only the individual domain has a direct path to health and risk behaviors. The end result is a health outcome or risk behavior by the individual that will, in turn, become a risk or protective factor itself. The authors state that this process is necessary for adolescent development and resilience (Blum et al., 2001).

Constructs of the Ecological Model

Adolescent risk and protective factors can be categorized within several domains or contexts. These domains interact with one another all the while being influenced by and interacting with the environment and time. This non-reclusive model provides a dynamic look at antecedents to adolescent health and risk behaviors. Due to the complexity of the Ecological Model, some constructs were excluded from the current research. An effort was made, however, to include risk

and protective factors from each of the domains as potential predictors of adolescent risk and health outcomes.

Individual Context

Once narrowly considered to be based solely on biology or genetic influences, the individual domain has evolved to include psychosocial components. The current view of the individual context is composed of those biological, psychological, and social attributes that influence individual behavior. At the level of the individual, Blum and associates (2001) identify different risk and protective factors of adolescent health outcomes or risk behavior based on empirical research and extensive literature reviews.

Supported by current research, individual risk factors include, but are not limited to: biological vulnerability (e.g. family history of alcoholism), aggressive temperament and behavior, impulsivity, and perception of risk (Petronyte, Zaborskis, & Veryga, 2007). Alternatively, protective factors include spirituality, intelligence, high self-efficacy, and perceived importance of parents (Beato-Fernandez, Rodriguez-Cano, Belmonte-Liario, & Pelayo-Delgado, 2005; Kliewer & Murrelle, 2007; Walker, AINETTE, Wills, & Mendoza, 2007).

Blum and associates (2001) make a point that not all factors are mutually exclusive as risk or protective factors, however, each antecedent may be identified as risk or protective depending on definition of terms or the developmental stage of the adolescents of study. Finally, risk and protective factors are not necessarily conceptual opposites, but rather the interaction between the two creates a unique ratio of risk to protective mechanisms. For example, within the social context,

access to substance is viewed as a risk factor while access to health care is a protective factor. These two factors are not opposites and have the potential to both be present at varying degrees.

In this research, the individual context refers to the biological, psychological, and social influences, classified as risk and protective factors, which influence health and risk behavior. The individual context is comprised of attitude toward tobacco or alcohol, propensity for taking risks, perception of risk, religiosity, and participation in employment outside of the home. The individual context interacts with the family, school, and social contexts, and has a direct effect on health and risk outcomes.

Family Context

The family context is defined as social environment in which the adolescent was raised or spends a great deal of time. The family context has the potential to influence behavior and provide support to the adolescent. This environment is made up of several concepts that can be classified into risk and protective factors. Large family size, overcrowding, poverty, and exposure to violence were identified as some possible risk factors by Blum and associates (2001) and others (Kliewer & Murrelle, 2007; Petronyte et al., 2007; Walker et al., 2007). Conversely, parental presence, family cohesion, and strong parental values related to school and risk behavior were identified as protective factors for health risk behaviors in adolescents (Arthur et al., 2002; Kliewer & Murrelle, 2007; Walker et al., 2007). Two constructs from the family context, parental presence and support, were included in this research.

Peer Context

The peer system is unique to adolescents in that they can be greatly affected by the interactions and beliefs of the peers. The peer context is defined as the self-selected social environment of the adolescent that has the potential to support or influence adolescents' attitudes, opinions, and feelings about themselves, their families, society, and the environment. Part of the social context within the Ecological Model, peers have been shown to influence adolescents in different ways to produce both positive and negative health outcomes (T. Jackson, 2006; Zambon, Lemma, Borraccino, Dalmasso, & Cavallo, 2006). Specific risk factors in this domain identified by Blum (2001) and others are perception of threat, social isolation, participation in deviant culture, and prejudices (Godley, Passetti, & White, 2006; Kliewer & Murrelle, 2007). Two constructs from the peer context, peer influence and peer environment, are explored in this research.

School Context

The school domain is very important in adolescents as most spend a great deal of time in the educational system. The school context is defined as the environment and influencing factors in a place of formalized education. While all schools are unique, several antecedents to health risk and health behavior outcomes were identified by Blum and colleagues (2001). Risk is potentiated by size of school, absenteeism, and poor academic performance (Bisset, Markham, & Aveyard, 2007; Case, 2007; Cox, Zhang, Johnson, & Bender, 2007; Petronyte et al., 2007). However, protection is increased if adolescents were highly connected to school, exhibited a high grade point average (GPA), and adhered to school

policies (Beato-Fernandez et al., 2005; Gau et al., 2007; Nelson & Gordon-Larsen, 2006). Determinants from the school context used in this research are academic performance, connectedness or attachment to school, and safety at school. High school program, competition for grades, connectedness or attachment, and peer environment are examined to compromise the overall school environment.

Social Context

The social context or immediate social environment refers to the built surroundings, social surroundings, and community policies. Related to the school and family contexts, the immediate social environment takes into account the social climate as well as immediate surroundings not directly controlled by the adolescent or family. The peer context is part of the social context. Risk factors include poverty, single parent household, exposure to violent media and neighborhood, access to drugs and other substances, peer influence, and television/video watching (Kliewer & Murrelle, 2007; Nelson & Gordon-Larsen, 2006). Protective factors identified in existing research include school enrollment, access to health care facilities, presence of religious institutions, and access to role models (Kliewer & Murrelle, 2007; Verkooijen, de Vries, & Nielson, 2007). Immediate social environment constructs are included in this research. Access to substance, television viewing, peer influence, and perceived environmental safety are included.

Macro-level Environment

Finally, the macro-level environment is the most overarching and general construct in the model. Defined as political influences, historical events, and macro-level economics that influence adolescent's behavior, the macro-level environment has the potential to influence all other domains either directly or indirectly (individual context, social context, school context, or family context). Blum and colleagues (2001) identified four determinants at the macro-societal level that either positively or negatively influences adolescent behavior. Political realities, youth laws and policies, macro-level economics, and historical events are not specifically categorized as risk or protective factors but have the potential to affect adolescents related to health risk and health behavior outcomes (Arthur et al., 2002). In this research three time points (1992, 1999, and 2004) are conceptualized as a proxy for historical events and political initiatives.

Health risk behaviors and youth health outcomes

Health risks are those behaviors that put adolescents at higher risk for disease, injury, and death. Health risks were divided by Blum into four categories: Substance abuse, diet and exercise, injury and violence, and sexual and reproductive risks. Alternatively, youth health outcomes are those outcomes that move the adolescent towards overall physical, emotional, and social health. The interaction of the risk and protective factors in each of the identified contexts impacts and influences adolescent behavior.

In Blum's model (2001), all contexts and the macro-level environment interact to impact the individual context which is the only context that has a direct

path to health or risk behavior. Ultimately, an adolescent either participates in a health risk behavior or achieves a positive health outcome. In this research two health risk behaviors are explored: tobacco use and alcohol use. Physical activity is examined as a health outcome as well as a moderator or protective factor for substance use.

Ecological Model Related to Proposed Models

In an effort to examine the phenomena of physical activity and risk and protective factors in adolescents from a broad perspective, three models were developed based on the Ecological Model and relevant literature. The first two models examine the relationship of physical activity, identified risk or protective factors, and substance use, specifically tobacco and alcohol. Additionally, the first two models explore physical activity as a moderator or protective factor for substance use. The third model looks is a historical comparison to examine physical activity as an outcome at three specific time points to assess macro-level involvement or influence on risk and protective factors and predictors of physical activity.

A main difference between Blum's Ecological Model (2001) and the proposed models is the direction and path of influence. The Ecological Model indicates that the risk and protective factors in each domain interact to have a direct or indirect influence on the individual context. In this model, only the individual context directly influences behavior. In contrast, the proposed models used in this research posit that all contexts may have a direct or indirect effect on

specific outcomes. Finally, the strengths of these influences may be moderated by physical activity, gender, age, and race/ethnicity.

The Ecological Model of Adolescent Health Risk Behaviors provides a strong framework and background for the examination of risk and protective factors as they relate to health risk behaviors and youth health outcomes (Blum et al., 2001). The examination of the dynamic interactions between risk and protective factors while influenced by the environment can lead to further understanding of adolescent behavior. Tobacco use, alcohol use, and physical activity in adolescence will be explored as outcomes. Specific domains, family, social, school, peer, and individual, will be examined in the context of immediate social environment and macro-level environment to identify risk and protective factors that are most predictive of risk behaviors and health outcomes. Finally, physical activity will be examined as a protective factor itself - as a buffer or moderator of substance use.

Research Questions

Three separate, but related, studies will examine the risk and protective factors from the Ecological Model as they are related to physical activity and substance use in adolescents.

Study 1: Risk and Protective Factors, Physical Activity, and Tobacco Use

Research Question 1: What is the relationship between risk and protective factors, physical activity, and tobacco use in adolescents (Figure 2)?

Aim 1: To identify individual, social, family, and school predictors of physical activity and tobacco use in adolescents.

Aim 2: To describe the effects of physical activity and the individual context, social context, family context, and school context factors, including determining whether there are statistical interactions (moderation) between physical activity and specific factors in their effects on tobacco use.

Aim 3: To examine differences in predictors of physical activity and tobacco use by gender, grade, and race/ethnicity.

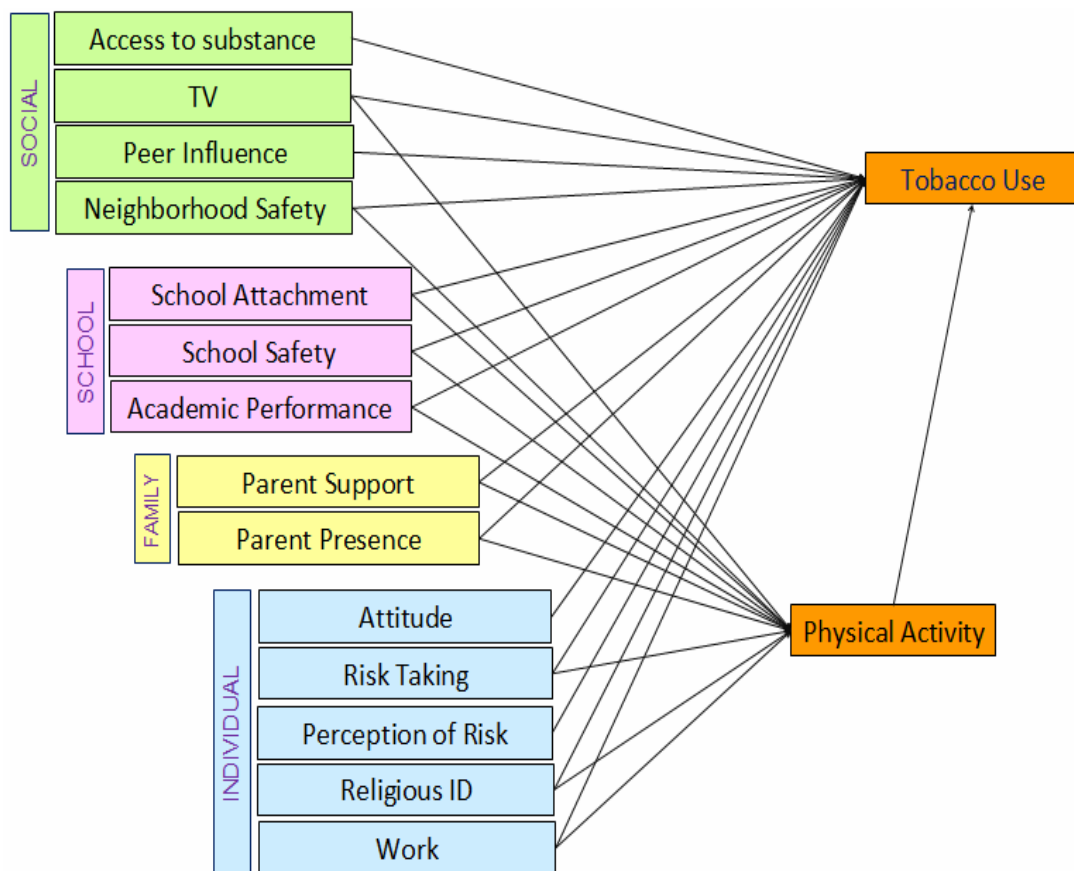


Figure 2- Model of Risk and Protective Factors, Physical Activity, and Tobacco Use

Study 2: Risk and Protective Factors, Physical
Activity, and Alcohol Use

Research Question 2: What is the relationship between risk and protective factors, physical activity, and alcohol use (Figure 3)?

Aim 1: To identify individual, social, family, and school predictors of alcohol use in adolescents.

Aim 2: To describe the effects of physical activity and the individual context, social context, family context, and school context factors on alcohol use, including determining whether there are statistical interactions (moderation) between physical activity and specific factors in their effects on alcohol use.

Aim 3: To examine differences in predictors of physical activity and alcohol use by gender, grade, and race/ethnicity.

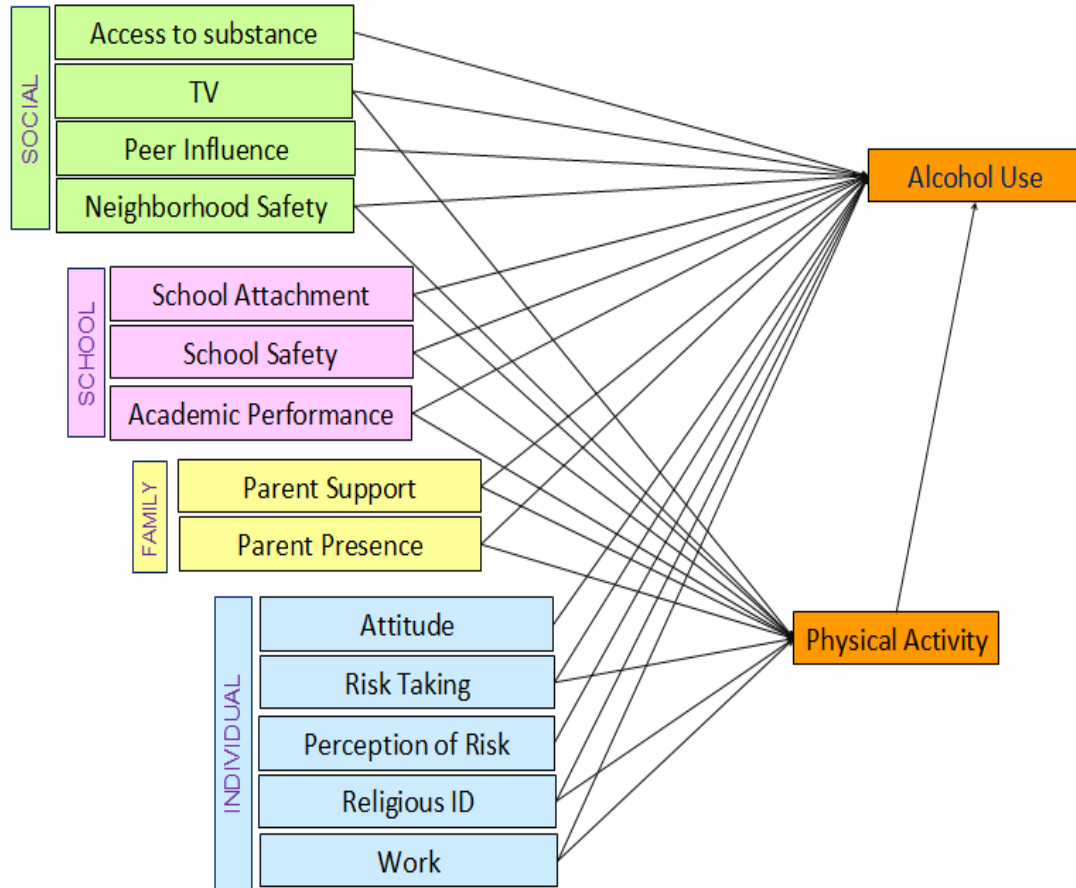


Figure 3- Model of Risk and Protective Factors, Physical Activity, and Alcohol Use

Study 3: Environmental Risk and Protective

Factors and Physical Activity

Research Question 3: What is the relationship between the environmental factors and self-reported physical activity over time (Figure 4)?

Aim 1: To determine which environmental risk and protective factors are predictive of physical activity in 1992, 1999, and 2004.

Aim 2: To compare the prediction equations across years.

Aim 3: To examine trends, similarities, and differences in perceived environment and physical activity over time.

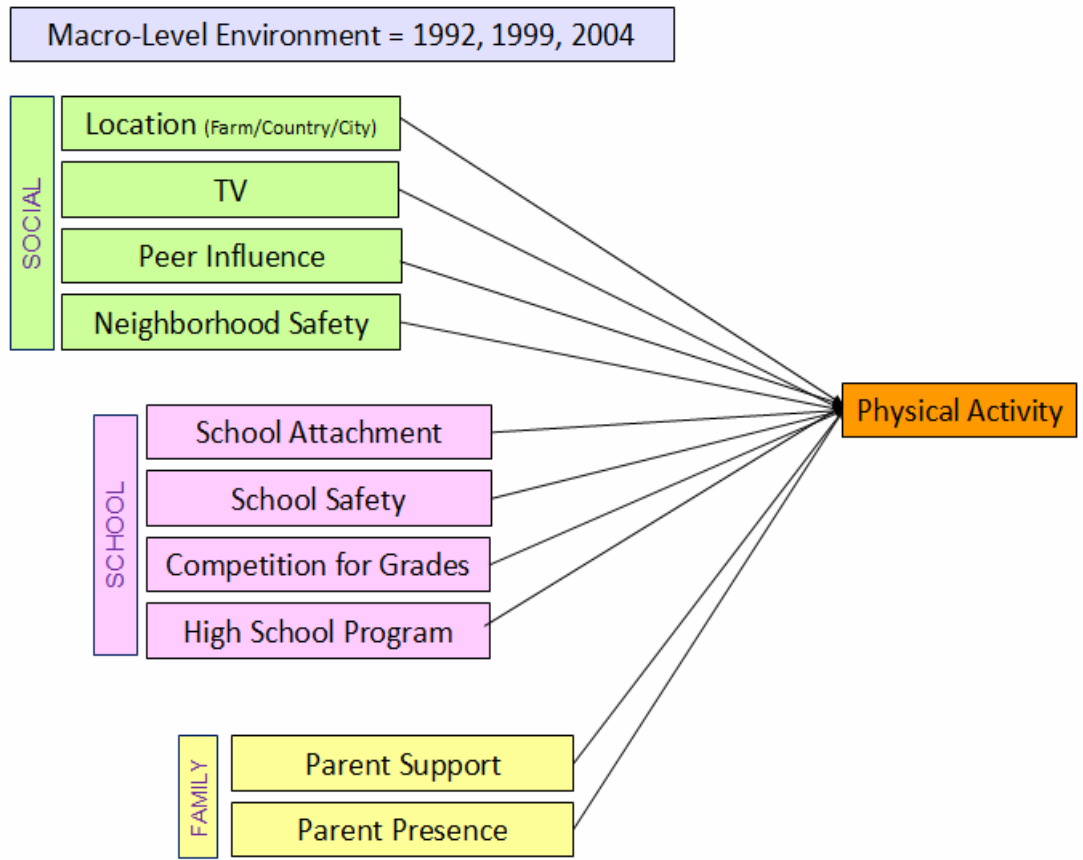


Figure 4- Model of Environmental Risk and Protective Factors and Physical Activity

Methodology

This research was conducted using data from the national Monitoring the Future (MTF) project (Johnston, O'Malley, Bachman, & Schulenberg, 2007). The MTF project was initially established to examine and study changes in the beliefs, attitudes, and behavior of young people in the United States. Initiated in 1975, MTF annually surveys 12th grade adolescents related to drug and alcohol use, demographic information, and questions regarding values, behaviors, and lifestyle orientation. The project added 8th and 10th grade students to the sample in 1991. This study surveys the same segment of the population annually providing cross sectional data. This original study was funded by the National Institute on Drug

Abuse through the National Institutes of Health. This project mainly reports on drug and alcohol use in American youth and attempts to explore the direction and rate of change over time. Four different survey forms are utilized in national data collection.

Data were accessed via the public database from the Institute for Social Research at the University of Michigan in Ann Arbor. A multi-stage random sampling method is utilized. In the first stage particular geographic areas are selected. Next, one or more schools is selected in each area. Finally, classes are randomly selected within the school with a maximum of 350 students included from each school. When schools have fewer than 350 students, all students are included in the sample. Data is collected in the spring of each school year.

Prior to the administration of the survey, flyers are distributed to students in school to explain the purpose and procedure of the survey. Additionally, letters are sent to the parents of the adolescents to allow for opportunity to decline participation. Surveys are conducted in school during normal class time under the supervision of the local Institute for Social Research and University researchers following a standardized procedure manual. All data has been entered, cleaned, and managed in a publicly accessible database utilizing SPSS, SAS, and Stata.

The following research models utilize the SPSS version of the data. IRB approval was obtained for the original research as well as this research study (HUM00019048). Data collected from 8th and 10th graders was utilized for these studies. While MTF has four different survey forms, only form one respondents were included in these studies in an effort to assure consistency of questions

across grades and years. The first and second studies will use data from 2004 only (Total N=11,432; 8th grade N=5826; 10th grade N=5606). The third study again only uses form one data. In this study, however, 8th and 10th grade data will be used from 1992, 1999, and 2004 (Total N=39,130; 1992 8th grade N=9501, 10th grade N=7843; 1999 8th grade N=5745, 10th grade N=4609; 2004 8th grade N=5826, 10th grade N=5606).

Physical Activity, Risk and Protective Factors, and Substance Use

The first and second studies focus on physical activity as it relates to previously identified risk and protective factors and substance use. The overarching goal of the studies is to determine the relationship between risk and protective factors, physical activity, and substance use. Additionally, physical activity is explored to determine if it has a moderating effect on tobacco use or alcohol use.

Risk and protective factors from each context in the Ecological Model are examined in this research. Individual, social, family, and school contexts are included in the model. Elements from the peer context in the Ecological Model are considered within the social context in this research. Individual factors explored in this model are attitude toward substance, perception of risk of the substance, propensity for risk taking, and employment outside of the home. Social risk factors are access to substance, television viewing, neighborhood safety, and peer pressure for substance use. Parent support and parental presence are studied within the family context. Within the school context, connectedness or attachment to school, school safety, and academic performance are examined.

In a third and final study, physical activity is explored as it is related to environmental risk and protective factors over time. Specifically, three time points are used: 1992, 1999, and 2004. Environmental factors are adapted from the Ecological Model and divided into three contexts: Environment safety, home environment, and school environment. Safety will be examined from the school and neighborhood perspectives. The home environment consists of parent involvement or presence, television viewing, and the location of the family home (farm, city, or country). Finally, school factors that will be tested are specific type of high school program, connectedness or attachment to school, peer influence or environment, and competition for grades.

Summary

Lack of physical activity has long been a problem for adolescents in the United States. Due to these poor physical activity levels, chronic diseases and obesity are on the rise. While previous research has focused on barriers to physical activity, results are not consistently supported in the literature. Interventional research has focused on gender and school based interventions, however the results are mixed. Studies that look at risk and protective factors in adolescents often limit outcomes to only risk behaviors such as tobacco and other substance use. Few studies have examined the relationship of physical activity to risk behaviors and even fewer studies have explored the idea of physical activity itself as a protective factor or moderator for these risky behaviors. Finally, environmental risk and protective factors have not been adequately explored in

past research. Limited studies have looked at environmental risk and protective predictors of physical activity over time.

The three following studies examine physical activity and risk and protective factors in a nationally representative adolescent population. Risk and protective factors as they relate to physical activity, tobacco use, and alcohol use are explored. Predictors are identified and evaluated for differences between gender, grade, and race/ethnicity. The moderating effects of physical activity, gender, grade, and race/ethnicity are investigated. Finally, environmental risk and protective factors are examined in a novel way by comparing predictive factors of physical activity over time.

Guided by the Ecological Model, these studies are important efforts in exploring the potential hidden benefits of physical activity that have not been adequately studied. Examination of physical activity as it relates to the dynamic interaction between risk and protective factors and substance use while being influenced by the environment can provide researchers with further understanding of adolescent behavior. Additionally, these studies attempt to address some of the research gaps related to the complex interactions between risk and protective factors, physical activity, and substance use. The exploration of these relationships may help to guide future intervention studies. Finally, these studies add to the body of evidence related to the emerging idea that physical activity may play a significant role in reducing risky behavior by a variety of mechanisms: as a protective factor itself, as a buffer for known risk factors, and as an alternative behavior for risky behaviors.

Chapter 2

Risk and Protective Predictors of Physical Activity and Tobacco Use in Adolescents

Introduction

Adolescence is a time for the development of risk and protective health behaviors. Behaviors and practices that begin in adolescence may carry over into adulthood and can have an impact on the development of chronic disease. Two such important behaviors, one risk and one protective, are tobacco use and physical activity.

The CDC reports that more than half of adolescents have experimented with smoking (Eaton et al., 2006). When other tobacco products are included (smokeless tobacco, cigars), 28.4% of high school students currently engage in tobacco behavior. The proportion of males and females who have tried cigarettes is similar (males 55.9%, females 52.7%) while more boys (31.7%) are regular users of tobacco as compared to females (25.1%). An alarming 54.3% of high school students say that they have tried smoking at least once and 13.4% claim that they have smoked at least one cigarette per day for at least 30 days (Eaton et al., 2006). Although most students (54.6%) try to quit smoking, not all are successful.

In contrast, physical activity rates have declined over the years despite efforts aimed at increasing exercise among adolescents. In 2005, only 35.8% of

adolescents met the current recommendation of physical activity for 60 minutes per day on at least five out of the last seven days (CDC, 2005; Eaton et al., 2006). Furthermore, only 27.8% of girls received the recommended daily physical activity while 43.8% of boys met the guidelines. National recommendations for physical activity continue to increase due to the fact that studies have shown that more people participate in physical activity when recommended levels are higher (Jeffery, Wing, Sherwood, & Tate, 2003). However, these increased recommendations have not had the desired effect among adolescents.

Investigation into reasons for participation in physical activity and use of tobacco can aid researchers in the development of interventions aimed at improving adolescent and, ultimately, adult health. Furthermore, identification of predictors of these behaviors and evaluation of potential relationships may provide interesting results. While both tobacco and physical activity have been studied separately, minimal research has examined their relationship and mutual influence. The purpose of this study is to examine predictors of tobacco use and physical activity in adolescents from an ecologic perspective.

Theoretical Framework and Literature Review

The Ecological Model of Adolescent Health Risk Behavior is the organizing framework for this research. The individual context, family context, the social context, school context, and the macro-level environment all play a role in influencing health risk behaviors or positive health behaviors. Previous research on risk and protective factors and predictors of adolescent behavior will be examined within each context.

Physical Activity and Tobacco Use

Considerable research has examined the correlations between smoking and physical activity. Physical activity, generally measured in frequency, intensity, and duration, may be classified as light, moderate, or vigorous activity. Light intensity physical activity could be a slow walk, gardening, or light stretching. Moderate activities cause an increase in breathing or heart rate, such as brisk walking, dancing, or a bicycle ride on flat terrain. In vigorous activity, however, it is difficult to maintain a conversation, such as jogging, swimming laps, or circuit training. As may be expected, physical activity is often negatively correlated with smoking behavior in both adults and adolescents (Aaron et al., 1995; Cox et al., 2007; Kulbok & Cox, 2002; Plotnikoff, Bercovitz, Rhodes, Loucaides, & Karunamuni, 2007; Wilson et al., 2005). Physical activity, conceptualized of sport participation and outdoor activities, accounted for seven percent of the variance of cigarette smoking in one study (Thorlindsson & Vilhjalmsen, 1991). Those adolescents who were physically active were less likely to use or initiate use of tobacco.

In contrast, another study found that an increase in physical activity was positively correlated with an increase in smoking. Individuals who are extrinsically motivated to participate in exercise, such as with organized sport teams or encouragement from others, were more likely to smoke (Rockafellow & Savies, 2006). Although not directly addressed, the potential peer influence cannot be overlooked for college aged students. While the study was done with older adolescents and young adults, results emphasize the complex relationship

between physical activity and smoking. This relationship has the potential to be unique to high school aged adolescents and warrants further study.

In one longitudinal study that examined adolescents as they developed into adults, an inverse relationship between physical activity and smoking was observed at all time points over a 13 year period (Paavola, Vartiainen, & Haukkala, 2004). This seemingly protective nature of physical activity has been supported by research that examines the relationship of physical activity and other health or risk behaviors. Adolescents who regularly participated in physical activity seemed to be more resistant to substance use, including tobacco use (Kirkcaldy, Shephard, & Siefen, 2002). Finally, exercise explained nearly eight percent (7.5%) of the variance in adolescent risk behaviors indicating that physical activity may be a moderator or mediator for substance use in adolescents (Kulbok & Cox, 2002).

While the recommended guidelines for physical activity are 30 minutes for five or more days per week, any physical activity seems to have a protective role in substance use. Participation in just one team sport had a significant negative effect on smoking progression in high school adolescents (Audrain-McGovern, Rodriguez, Wileyto, Schmitz, & Shields, 2006). That is to say that those smokers or adolescents who were intending to smoke did not increase in frequency or use when involved in an organized sport. Additionally, adolescents who participated in an endurance sport on a regular basis used significantly less tobacco than those who did not engage in endurance sports (Kirkcaldy et al., 2002). Several potential explanations for the relationship between physical activity and tobacco use have

been offered. One study suggested that the protective power of physical activity may increase as the physical activity increases over time (Winnail, Valios, McKeown, Saunders, & Pate, 1995). Kirkcaldy and colleagues believe that the addictive effect of physical activity may take the place of other addictions, such as substance use and smoking, and warrants further study.

Finally, few studies have attempted to examine physical activity as a factor protective of tobacco use. Rodriguez and Audrain-McGovern (2005) examined the mediating and moderating effect of physical activity and global physical self-concept on adolescent smoking. Physical activity was shown to have an indirect effect on adolescent smoking. This study supports the possibility that physical activity may play a protective role in adolescent smoking but does not have a direct effect on smoking itself (Rodriguez & Audrain-McGovern, 2005). Correia, Benson, and Carey (2005) used physical activity as an alternative behavior for substance use. Subjects in the increased physical activity group showed a significant decrease in tobacco use (Correia, Benson, & Carey, 2005).

In many studies African American and Hispanic adolescent subgroups report less physical activity (Eaton et al., 2006; Gordon-Larsen et al., 2002; Gordon-Larsen, McMurray, & Popkin, 2000; Harris, Gordon-Larsen, Chantala, & Udry, 2006; Taylor et al., 1999; Whaley & Francis, 2006) and more tobacco use than Caucasian subgroups (Elder, Leaver-Dunn, Wang, Nagy, & Green, 2000; Rodriguez & Audrain-McGovern, 2005; Thorlindsson & Vilhjalmsson, 1991). However, race or ethnicity does not always explain a significant amount of the variance in tobacco use or physical activity (Ammouri, Kaur, Neuberger,

Gajewski, & Choi, 2007; J. Sallis, Prochaska, Taylor, Hill, & Geraci, 1999; Trost, Pate, Ward, Saunders, & Riner, 1999).

As with physical activity, most often sociodemographic variables account for a small amount of the variance in smoking behavior or are not significant at all (Elder et al., 2000; Rodriguez & Audrain-McGovern, 2005; Thorlindsson & Vilhjalmsen, 1991). These inconsistencies indicate that additional variables related to race and ethnicity may not have been examined or that ethnicity has effects on distal predictor variables such as self efficacy and intent to become active rather than outcome variables. Potential differences in race and ethnicity continue to warrant further study.

Consistently supported in the literature, however, is the fact that girls participate much less in physical activity than boys (Ammouri et al., 2007; Eaton et al., 2006; Frenn et al., 2003; Trost et al., 2002; Wu, Rose, & Bancroft, 2006). Many researchers have attempted to identify reasons for this discrepancy. Adolescent girls report different motivators and barriers for physical activity than adolescent boys. Lack of motivation, lack of access, gender and weight related bullying, male dominance in physical education classes, and concern for appearance or body shape emerged as individual barriers to physical activity in adolescent girl populations (Allender, Cowburn, & Foster, 2006; Amesty, 2003; Evenson, Scott, Cohen, & Voorhees, 2007; Gordon-Larsen et al., 2000; Robbins, Pender, & Kazanis, 2003)

Individual Context

The individual context is composed of those biological, psychological, and social attributes that influence individual behavior. In this study, the individual context is conceptualized as attitude toward tobacco use, perception of tobacco risk, risk taking behaviors, religious identity, and individual work behavior.

Adolescent attitudes toward tobacco influence individual tobacco use. Those adolescents who have a positive view of tobacco are more likely to smoke while those who disapprove of smoking are less likely to engage in tobacco use (Smith, Bean, Mitchell, Speizer, & Fries, 2007). These attitudes, however, are also influenced by the perceived risks of tobacco use, risk taking behavior, tobacco use of peers, and the perceived subjective norms. As expected, adolescents who perceive harmful effects from tobacco use are more likely to abstain from smoking (Robinson et al., 2006). In one study, all of the adolescents who were current smokers believed that smoking was not harmful (Bird et al., 2007). Additionally, adolescent smoking has been positively correlated with other risky behaviors, such as carrying a weapon, fighting, and drinking alcohol (Dowdell, 2006).

Another individual factor that has a potential effect on both physical activity and smoking is spirituality, religiosity, or belief in a higher power. A study conducted with adults found that participants who attended church weekly on a regular basis were more likely to be physically active than those participants who went to church less frequently (Merrill & Thygeson, 2001). Other adult studies, however, have found that personal religiosity or spirituality, not the

participation in a formalized religion, has a positive effect on behavior such as physical activity (Walker et al., 2007). Studies in adolescents, while few, have supported this finding. Youth that self-identify as more religious or spiritual are more likely to participate in sports or physical activity (Wallace Jr. & Forman, 1998). While correlational, this link may be due to the adolescent being more in touch with his or her body, participation in a more disciplined lifestyle, or the desire to do something that is good for one's body.

Religion or spirituality has also been shown to have an effect on smoking. In several studies adolescents who were more religious were less likely to use tobacco (Belcher & Shinitzky, 1998; Merrill & Thygeson, 2001; Walker et al., 2007). As with physical activity, it is the individual and personal aspect of religion and spirituality that had significant effects on smoking while the behavior of attending and participating in church was not significant (Walker et al., 2007). Religiosity also had indirect effects on adolescent substance use through good self-control and tolerance for deviance. These findings indicate that religion or spirituality may instill a specific set of social values that make adolescents less likely to use tobacco.

An adolescent's participation in work outside of the home also influences tobacco use. Higher hours of paid work is positively correlated with more tobacco use (Carriere, 2005; Godley et al., 2006; Thorlindsson & Vilhjalmsson, 1991). A possible explanation is that time away from parent supervision, access to money, and potential exposure to deviant culture could play a role. The

relationship between work and physical activity has not been well studied in adolescents and further examination into this possible relationship is needed.

Social Context

The social context, which includes the immediate or built environment as well as the social environment, has the potential to influence physical activity and smoking in a variety of ways. The immediate or built environment is defined as access to parks, neighborhood safety, and living surroundings. For example, the social context can effect adolescent behaviors directly or indirectly by influencing attitudes, beliefs, or social norms (Cohen, Scribner, & Farley, 2000). In this study, the social context consists of access to tobacco, peer influence, television use, and neighborhood safety.

Peer groups play a special role during adolescence. The peer group has influence on cognitive processes as well as behavior through modeling (Zambon et al., 2006). Peer behavior has a direct positive effect on physical activity and smoking behavior (Plotnikoff et al., 2007; Wu & Pender, 2002). Those adolescents who had friends who participated in physical activity were much more likely (O.R. 4.72, C.I 1.58-14.14, $p < .05$) to be active themselves than those whose peer group was not active (Saxena, Borzekowski, & Rickert, 2002). Likewise, those adolescents who had friends that engaged in risky behaviors, such as smoking, were more likely to participate in similar risky behaviors (Hawkins, Catalano, & Miller, 1992; Reininger et al., 2005).

Media and television, another component of the social context, has been reported to have a direct and indirect effect on adolescent behavior. There is

much support for the relationship between excessive television viewing hours and adolescent obesity due to physical inactivity (Gordon-Larsen et al., 2002; Hancox & Poulton, 2006; Janz, Dawson, & Mahoney, 2000; Ochoa et al., 2007).

Recent research reveals that television viewing or computer time in adolescence may be different than in other age groups. One study found that those adolescents who reported high levels of computer and television time also reported high levels of physical activity (Santos, Gomes, & Mota, 2005). Furthermore, there was no significant difference observed in television time between the active and inactive adolescent groups. These inconsistencies and potential differences between age groups and eras necessitate more research in an effort to explore the changing relationship between television use and physical activity participation.

Less studied, but equally important, is the relationship between smoking and exposure to television. Interestingly, one study found that exposure to R-rated films or having a television in the bedroom significantly predicted smoking in white adolescents (C. Jackson, Brown, & L'Engle, 2007). Another found that as the number of television hours increased weekly, the risk increased for earlier onset of smoking (Gutschoven & Van den Bulck, 2005).

Family Context

The family context and family interactions are important throughout adolescence. The family context is the social environment in which the adolescent was raised or spends a great deal of time. In this study specifically, the family context is defined as parental support and parental presence.

Family and parent support has been shown to significantly and positively affect physical activity (Dowda, Dishman, Pfeiffer, & Pate, 2007; Heitzler, Martin, Duke, & Huhman, 2006; Raudsepp, 2006). Higher levels of perceived family support by adolescents are associated with physical activity (Gustafson & Rhodes, 2006; Neumark-Sztainer, Story, Hannan, Tharp, & Rex, 2003; Simantov, Schoen, & Klein, 2000). In one study family support explained six to ten percent of the variance in physical activity depending on age of the adolescent (J. Sallis et al., 1999). Family support is also related to smoking behavior in adolescents. Perceived support from parents has been shown to have a significant negative effect on smoking and other substance use (Walker et al., 2007). Furthermore, family conflict, poor family bonding, and lack of consistent discipline were associated with higher risk of smoking and substance use (Hawkins et al., 1992).

School Context

The school is another area that has elicited much research related to physical activity and smoking. The school context is conceptualized as the environment and influencing factors in a place of formalized education. In this study, the school context consists of academic performance, school attachment, and school safety.

In general, higher academic achievement and higher grades are associated with lower reports of smoking (Belcher & Shinitzky, 1998; Gau et al., 2007) while academic failure or low academic achievement is associated with an increased risk of tobacco use (Cox et al., 2007; Hawkins et al., 1992). In fact, in one study, educational performance and beliefs, specifically “homework not being

done” and “lower academic standing”, explained nearly 10% of the variance in smoking behavior (Thorlindsson & Vilhjalmsson, 1991). In another study, average grades of a B or better were associated with decreased risk of adolescents engaging in health risk behaviors, such as smoking (Kaplan et al., 2003). Finally, lower academic performance has been reported as more prevalent in smokers than non-smokers (Cox et al., 2007).

Academic achievement has also been associated with higher levels of physical activity. Schmitz and colleagues(2002) found that a higher academic rank was predictive of higher levels of physical activity. Adolescents who reported high levels of exercise also reported higher grade point averages than those with lower reported exercise in another study (Field, Diego, & Sanders, 2001). Additionally, those adolescents who were involved in a team sport had higher grades than were expected as well as an increased probability of attending college, more enjoyment of school, and more connectedness to school (Eccles & Barber, 1999; Field et al., 2001).

School connectedness or attachment, or participation in the school community and resources, enjoyment of school, and the belief that school is interesting and important, is another concept within the school context that influences adolescent behavior (Wang, Matthew, Bellamy, & James, 2005). Being active in school has been associated with less engagement in risky behaviors (Nelson & Gordon-Larsen, 2006) while low commitment or connection to school has been moderately correlated with higher risk of smoking (Hawkins et al., 1992). One study reports that school connectedness has a significant negative

direct effect on substance use in both boys and girls (Wang et al., 2005). Participation in school activities, organizations, clubs, and sports deters adolescent tobacco use. Adolescents who participated in as little as one to two organized school groups were two times less likely to smoke than those adolescents that did not participate (Elder et al., 2000; Larson, Story, Perry, Neumark-Sztainer, & Hannan, 2007). In contrast, school disengagement, or lack of participation, was found to be associated with an increased risk of tobacco use and other risky behaviors (Kliewer & Murrelle, 2007).

In summary, physical activity and tobacco use are important issues in adolescence. The majority of research studies have focused separately on these two phenomena. Few studies, however, have explored the relation of smoking and physical activity with other risk and protective factors. Research that examines the relationship of protective factors and risk behavior often does not include physical activity (Jessor, Van Den Gos, Vanderryn, Costa, & Turbin, 1995). Physical activity is a health promoting behavior and research needs to examine its relationship with other health protective factors and risk behaviors. Furthermore, ecologic models are seldom used as frameworks for adolescent risk and health behavior.

The purpose of this study is to examine the relationship of risk and protective factors, specifically physical activity and tobacco use, among adolescents. First, predictors of physical activity will be investigated. Next, the study will determine the predictors of tobacco use. Finally, physical activity as a

moderator for tobacco use in adolescents will be explored. Differences in gender, grade, and race/ethnicity will also be evaluated.

Methods

This study is a secondary analysis using data from a national survey designed to study attitudes, beliefs, and behaviors of adolescents across the country. The Monitoring the Future (MTF) project is a survey of adolescents comprised of a nationally representative sample of the middle and high school population the United States. Survey procedures are described elsewhere(Johnston et al., 2007).

This study was approved by the University of Michigan Institutional Review Board (HUM00019048). Data for this study are from the public database from the Institute for Social Research at the University of Michigan in Ann Arbor. Only data collected from 8th and 10th graders in 2004 on survey form one were utilized to assure consistency of questions. The total sample size was 11,432 (8th grade N=5826, 10th grade N=5606).

As described in Chapter 1, the organizing framework for this study was the Ecological Model of Adolescent Health Risk Behaviors. Although this model has not been extensively explored in physical activity and tobacco use research, many researchers recommend evaluation of the environmental theories and constructs to explore antecedents to health and risk behavior.

Measures

Empirical measures related to these contexts are described. All measures were self-report and utilized three to seven point Likert scales (Table 1). The

means of some questionnaire items were combined to create new variables. Internal consistency reliability was acceptable for all variables. Reliability coefficients at or near 0.70 are acceptable although higher values indicate higher reliability (Polit, 1996). Physical activity and tobacco use were outcome variables.

Table 1-Construct Items Utilized in Tobacco Model

Context	Construct	Questionnaire Item
Individual	Attitude (8 th grade alpha=.70, 10 th grade alpha=.72)	2 items: -Individuals differ in whether or not they disapprove of people doing certain things. Do you disapprove of people smoking one or more packs of cigarettes per day? (“Don’t disapprove (1)” to “Strongly disapprove (3)”) - Individuals differ in whether or not they disapprove of people doing certain things. Do you disapprove of people using smokeless tobacco regularly? (“Don’t disapprove (1)” to “Strongly disapprove (3)”) -Higher score indicates higher disapproval
	Perception of smoking risk (8 th and 10 th grade alpha=.71)	2 items: - How much do you think that people risk harming themselves (physically or in other ways) if they smoke one or more packs of cigarettes per day? (“No Risk (1)” to “Great Risk (4)”) - How much do you think people risk harming themselves (physically or in other ways) if they use smokeless tobacco each day? (“No Risk (1)” to “Great Risk (4)”) -Higher score indicates greater risk perceived
	Risk taking propensity (8 th grade alpha=.79, 10 th grade alpha=.80)	2 items: - Do you agree or disagree with each of the following: I get a real kick out of doing things that are a little dangerous (“Disagree (1)” to “Agree (5)”) - I like to test myself every now and then by doing something a little risky (“Disagree (1)” to “Agree (5)”) -Higher score indicates greater risk taking propensity
	Religious	2 items:

	identity (8 th grade alpha=.75, 10 th grade alpha=.77)	-How often do you attend religious services? (“Never (1)” to “About once a week or more (4)”) - How important is religion in your life? (“Not important (1)” to “very important (4)”) -Higher score indicates higher religious identity/spirituality
	Work	On the average over the school year, how many hours per week do you work in a paid job? (“none (1)” to “more than 30 hours per week (8)”) -Higher score indicates more hours worked per week
Social	Access to tobacco	How difficult do you think it would be for you to get each of the following types of drugs, if you wanted some: cigarettes? (“Probably impossible (1)” to “Very easy (5)”) -Higher score indicates greater perceived access
	TV (8 th grade alpha=.74, 10 th grade alpha=.76)	2 items: - How much TV do you estimate you watch on an average WEEKDAY? (“None (1)” to “Five hours or more (7)”) - How much TV do you estimate you watch on an average WEEKEND? (“None (1)” to “Nine hours or more (7)”) -Higher score indicates more TV watched
	Peer influence	How much pressure do you feel from your friends and schoolmates to smoke cigarettes? (“None (1)” to “A lot (4)”) -Higher score indicates greater pressure
	Neighborhood Safety	How often do you feel unsafe going to or from school? (“Never (1)” to “Everyday (5)”) -Higher score indicates less perceived safety
Family	Parental presence	On average, how much time do you spend after school each day at home with no adult present? (“None or almost none (1)” to “More than five hours (6)”) -Higher score indicates less parental presence at home
	Parental support (8 th grade alpha=.65, 10 th grade alpha=.62)	2 items: - How often do your parents check to see if homework is done? (“Never (1)” to “Often (4)”) - How often do your parents help with homework when it is needed? (“Never (1)” to “Often (4)”) -Higher score indicates greater perceived parent support
School	School attachment	3 items: - Thinking back over the past year in school, how

<p>(8th grade alpha=.77, 10th grade alpha=.76)</p>	<p>often did you enjoy being in school? (“Never (1)” to “Almost always (5)”)</p> <ul style="list-style-type: none"> - Thinking back over the past year in school, how often did you find your schoolwork interesting? (“Never (1)” to “Almost always (5)”) - Thinking back over the past year in school, how often did you hate being in school? (“Never (1)” to “Almost always (5)”Item reverse scored) <p>-Higher score indicates greater school attachment</p>
<p>School safety (8th grade alpha=.79, 10th grade alpha=.78)</p>	<p>7 items:</p> <ul style="list-style-type: none"> - How often do you feel unsafe when you are at school? (“Never (1)” to “Everyday (5)”) - During the last 12 months, how often has something of yours (<\$50) been stolen? (“Not at all (1)” to “5 or more times (5)”) - During the last 12 months, how often has something of yours (>\$50) been stolen? (“Not at all (1)” to “5 or more times (5)”) - During the last 12 months, how often has someone deliberately damaged your property? (“Not at all (1)” to “5 or more times (5)”) - Has someone injured you with a weapon? (“Not at all (1)” to “5 or more times (5)”) - Has someone injured you without a weapon? (“Not at all (1)” to “5 or more times (5)”) - Has someone threatened you with injury, but not actually injured you? (“Not at all (1)” to “5 or more times (5)”) <p>-Higher scores indicate less perceived school safety</p>
<p>Academic performance (8th grade alpha=.67, 10th grade alpha=.66)</p>	<p>6 items:</p> <ul style="list-style-type: none"> - Which of the following best describes your average grade in school this year? (“A (9)” to “D or below (1)”) - Thinking back over the past year in school, how often did you fail to complete or turn in your assignments? (“Never (1)” to “Almost always (5)” Item reverse scored) - Did you ever attend summer school to make up for poor grades or keep from being held back? (“No (1)” to “Yes, three or more summers (4)” Item reverse scored) - Have you ever had to repeat a grade in school? (“No (1)” to “Yes, two or more times (3)” Item reverse scored) - Have you ever been suspended or expelled from school? (“No (1)” to “Yes, two or more times (3)”

		Item reverse scored) - How often do you try to do your best work in school? (“Never (1)” to “Almost always (5)”) -Higher score indicates higher academic performance
Physical Activity	(8 th grade alpha=.68, 10 th grade alpha=.75)	2 items: - To what extent have you participated in the following school activities during this school year: athletic teams? (“Not at all (1)” to “Great (5)”) - How often do you actively participate in sports, athletics, or exercise? (“Never (1)” to “Almost every day (5)”) -Higher scores indicate higher levels of physical activity
Tobacco use	(8 th grade alpha=.82, 10 th grade alpha=.86)	4 items: - Have you ever smoked? (“Never (1)” to “Regularly now (5)”) - How frequently have you smoked cigarettes during the last 30 days? (“Not at all (1)” to “Two or more packs per day (7)”) - Have you ever taken or used smokeless tobacco? (“Never (1)” to “Regularly now (7)”) - How often have you taken smokeless tobacco during the past 30 days? (“Not at all (1)” to “More than once a day (6)”) -Higher scores indicate greater tobacco use

Physical activity was measured with two questions that quantified the extent to which adolescents participated in exercise and organized school sports. A combined general physical activity score was created by taking the mean of these two questions. Physical activity was then transformed into sedentary, low, and high groups based on natural breaks in the data and national physical activity guidelines. The sedentary group consisted of those adolescents who stated that they engaged in physical activity never to a few times per year or did not participate in school athletics. The low physical activity group answered participating in physical activity once or twice each month to once per week or a

slight to moderate participation in school athletics. Participants were classified in the high physical activity group if they stated that they were active nearly every day or if they participated in school athletics a considerable amount or to a great extent. Tobacco use was measured by four questions that ask adolescents if they have ever smoked cigarettes or used smokeless tobacco and the frequency of use in the past 30 days. A tobacco use variable was created by taking the mean of these four questions. Tobacco users are defined as those adolescents who smoked any amount of cigarettes or used smokeless tobacco over the past 30 days or self identified as a “regular user.”

Five constructs were measured in the individual context. Perception of tobacco risk, attitude toward cigarettes and smokeless tobacco, spirituality or religion, adolescent paid work, and risk taking propensity are included in this model. Four concepts were included within the social context. Access to substance, television viewing, peer influence to use substance, and neighborhood safety were examined in the model. Two concepts were included from the family context. Parental presence in the home and parental support of adolescent were evaluated. Finally, school context was measured by three factors. Academic performance, school attachment, and school safety were evaluated.

Sample Characteristics

Of the total 11,426 adolescents who were used for this study, approximately 51% were 8th grade students at the time of survey (N=5826) and 49% were 10th grade students (N=5606) (Table 2). In the eighth grade sample males and females were equally represented (males=48.9%, females=48.3%,

missing=2.8%). The majority of the sample was Caucasian (59.9%), followed by Hispanic (14.7%), and African-American (11.1%). More than three quarters of the sample lived in a city or town (75.7%) Approximately half of the students were enrolled at a college preparatory program or general high school (31.6%, 17.4% respectively). The majority of the students did not work for money outside of the home (65.9%). Twenty nine percent of 8th graders did not participate in organized athletics, while over half (55.2%) report that they get some form of daily exercise.

Table 2-Demographic Summary of Tobacco Model

	8 th Grade (N=5826) % (n)	10 th Grade (N=5600) % (n)
Gender		
Male	48.9 (2847)	46.9 (2627)
Female	48.3 (2816)	50.3 (2814)
Race/Ethnicity		
Caucasian	59.9 (3491)	61.3 (3434)
African American	11.1 (646)	12.6 (705)
Hispanic	14.7 (859)	15.6 (876)
Other/Missing	14.2 (829)	10.4 (585)
Environment		
Farm	5.4 (317)	3.8 (213)
Country	17.7 (997)	16.7 (937)
City/Town	75.7 (4410)	77.6 (4345)
Type of School		
College Prep	31.6 (1841)	47.3 (2647)
General HS	17.4 (1012)	23.8 (1330)
Voc/Tech	4.1 (237)	4.7 (264)
Other/Don't Know	42.9 (2499)	21.8 (1219)
Paid Job		
No Work	65.9 (3838)	63.4 (3548)
Work <5 hr/wk	18.3 (1065)	12.0 (670)

The tenth grade sample had similar demographic characteristics. Most adolescents were Caucasian (61.3 %), followed by Hispanic (15.6%) and African

Americans (12.6%). Nearly 80% (77.6%) lived in cities or towns. Almost half of the students were enrolled in a college preparatory program (47.3%) or general high school (23.8%). Most students did not have a job outside of the home (63.4%) or worked five or less hours per week (12.0%). Thirty five percent of students participated in organized athletics, while half (50.4%) reported that they get some form of daily exercise.

In general, eighth graders reported more television use and physical activity than tenth graders. Tenth graders reported more tobacco and alcohol use than eighth graders. Students who reported higher levels of physical activity also reported higher academic performance and grades, lower hours of television use, and higher levels of perceived parent support than those students with lower levels of physical activity. Complete physical activity responses are presented in Table 3. Tobacco responses are presented in Table 4. Full descriptive statistics of predictor and outcome variables are presented in Table 5. Descriptive statistics of physical activity groups are presented in Table 6.

Table 3-Physical Activity Participation

	8 th Grade (N=5826) % (n)	10 th Grade (N=5606) % (n)
No participation in organized athletics	33.8 (1689)	38.9 (1977)
Slight participation in organized athletics	8.5 (423)	7.5 (379)
Moderate participation in organized athletics	8.2 (409)	8.3 (444)
Considerable participation in organized athletics	9.3 (466)	9.7 (489)
Great participation in organized athletics	40.2 (2010)	35.7 (1822)
Never get exercise/PA	6.7 (386)	8.9 (507)
Exercise/PA a few times a year	9.5 (552)	11.4 (646)
Exercise/PA 1-2 x/month	8.0 (461)	9.2 (510)
Exercise/PA 1/week	20.2 (1166)	19.1 (1069)
Exercise/PA daily	55.6 (3217)	51.4 (2821)

Table 4-Tobacco Use

	8 th Grade (N=5826) % (n)	10 th Grade (N=5606) % (n)
Cigarettes		
Never smoke	70.9 (4133)	57.6 (3224)
Smoked 1-2 times	15.5 (908)	19.7 (1102)
Occasionally	3.2 (305)	9.8 (549)
Regularly in the past	2.8 (166)	4.7 (265)
Regularly now	3.3 (189)	6.4 (360)
Smokeless Tobacco		
Never	70.9 (4133)	82.1 (4597)
Smokeless 1-2 times	15.5 (906)	7.9 (422)
Occasionally	5.2 (305)	2.7 (153)
Regularly in the past	2.8 (166)	1.1 (60)
Regularly now	3.3 (189)	1.8 (103)

Table 5 -Descriptive Statistics of Variables, 2004

Variable	8 th Grade (N=5826) Mean (SD)	10 th Grade (N=5606) Mean (SD)
Smoking Attitude Based on Z score, 0=average response	-.0130 (.872)	-.0123 (.876)
Alcohol Attitude Based on Z score, 0=average response	-.0128 (.897)	.0001 (.881)
Risk Taking Based on Z score, 0=average response	.0002 (.884)	-.0069 (.917)
Religious ID Based on Z score, 0=average response	.0172 (.896)	.0339 (.899)
Attend religious services Never (1) to 1/wk+ (4)	2.87 (1.131)	2.81 (1.131)
Importance of religion Not important (1) to very important (4)	2.81 (1.027)	2.79 (1.055)
Work None (1) to 30+ hr/wk (8)	1.66 (1.321)	1.96 (1.643)
TV Based on Z score, 0=average response	.0136 (.888)	-.0003 (.896)
Hours of TV per day None (1) to 5+ hrs (7)	4.60 (1.657)	4.32 (1.637)
Hours of TV on weekend None (1) to 9+ hrs (7)	4.69 (1.567)	4.43 (1.535)
Neighborhood Safety Never unsafe (1) to unsafe everyday (5)	1.58 (.861)	1.58 (.838)
Parent Support	.004 (.682)	-.0075 (.853)

Based on Z score, 0=average response		
Parent Presence No time alone (1) to 5+ hrs alone per day (6)	2.77 (1.493)	2.96 (1.482)
School Attachment Based on Z score, 0=average response	-.002 (.832)	.0010 (.821)
School Safety Based on Z score, 0=average response	.0131 (.657)	-.0019 (.631)
Feel unsafe at school Never (1) to Everyday (5)	1.58 (.861)	1.70 (.864)
Academic Performance Based on Z score, 0=average response	-.0065 (.613)	.0026 (.608)
Expected Avg Grade A (9) to D or below (1)	6.22 (2.300)	6.00 (2.224)
Physical Activity Based on Z score, 0=average response	.0248 (.863)	.0032 (.894)
Daily activity Never (1) to Almost every day (5)	4.09 (1.269)	3.91 (1.371)
High School Athletics Not at all (1) to Great extent (5)	3.14 (1.767)	2.96 (1.773)
Tobacco Use Based on Z score, 0=average response	.0297 (.823)	.0134 (.775)
Regular smoker Never (1) to regularly now (5)	1.49 (.964)	1.81 (1.196)
Smokeless in last 30 days Not at all (1) to >1/day (6)	1.10 (.570)	1.13 (.691)
Alcohol Use Based on Z score, 0=average response	.5031 (.709)	.5426 (.684)
Ever Drink No (1); Yes (2)	1.45 (.498)	1.67 (.472)
Drink in last 30 days None (1) to 40+ (7)	1.32 (.843)	1.69 (1.154)

Table 6- Descriptive Statistics, Physical Activity Groups

Variable	Sedentary Group Mean (SD)		Low Physical Activity Mean (SD)		High Physical Activity Mean (SD)	
	8 th gr n=1767	10 th gr n=2044	8 th gr n=927	10 th gr n=1693	8 th gr n=2267	10 th gr n=1240
Smoking Attitude Based on Z score, 0=average response	-.0560 (.912)	-.0527 (.928)	-.0093 (.901)	.0401 (.973)	.0001 (.772)	.0009 (.784)
Alcohol Attitude Based on Z score, 0=average response	-.0483 (.951)	-.0030 (.892)	-.0172 (.893)	.0285 (1.001)	-.0041 (.808)	-.0066 (.799)
Risk Taking Based on Z score, 0=average response	.0288 (.625)	-.0484 (.954)	.0164 (.598)	-.0240 (.923)	.1629 (.841)	.0262 (.885)

Religious ID Based on Z score, 0=average response	-.1704 (.940)	-.1159 (.934)	-.0102 (.903)	.0907 (.879)	-.0692 (.839)	.1524 (.854)
Work None (1) to 30+ hr/wk (8)	1.56 (1.322)	1.97 (1.685)	1.57 (1.305)	2.10 (1.743)	1.76 (1.334)	1.87 (1.524)
TV Based on Z score, 0=average response	.1168 (.921)	.0544 (.943)	-.0131 (.907)	-.0192 (.876)	-.0692 (.839)	-.0721 (.861)
Hours of TV per day None (1) to 5+ hrs (7)	4.82 (1.655)	4.49 (1.709)	4.30 (1.503)	4.32 (1.602)	4.40 (1.579)	4.08 (1.544)
Hours of TV on weekend None (1) to 9+ hrs (7)	4.80 (1.656)	4.43 (1.607)	4.35 (1.620)	4.37 (1.531)	4.61 (1.478)	4.43 (1.475)
Neighborhood Safety Never unsafe (1) to unsafe everyday (5)	1.56 (.949)	1.67 (.894)	1.57 (.864)	1.62 (.857)	1.49 (.763)	1.47 (.716)
Parent Support Based on Z score, 0=average response	-.1200 (.777)	-.1142 (.871)	-.0977 (.799)	-.1013 (.851)	.1442 (.688)	.1318 (.817)
Parent Presence No time alone (1) to 5+ hrs alone per day (6)	2.80 (1.563)	3.03 (1.573)	2.91 (1.554)	3.10 (1.523)	2.76 (1.430)	2.81 (1.357)
School Attachment Based on Z score, 0=average response	-.1644 (.869)	-.1700 (.899)	-.0199 (.856)	.0199 (.817)	.1213 (.808)	.0968 (.778)
School Safety Based on Z score, 0=average response	.0267 (.659)	.0239 (.639)	-.0119 (.617)	.0176 (.679)	.0156 (.673)	-.0414 (.582)
Feel unsafe at school Never (1) to Everyday (5)	1.85 (.970)	1.81 (.931)	1.79 (.899)	1.73 (.832)	1.62 (.805)	1.59 (.776)
Academic Performance Based on Z score, 0=average response	-.1477 (.638)	-.1100 (.631)	-.0002 (.608)	-.0096 (.623)	.1399 (.565)	.1435 (.545)
Expected Avg Grade A (9) to D or below (1)	5.64 (2.474)	5.54 (2.304)	6.28 (2.321)	6.02 (2.207)	6.81 (1.974)	6.54 (2.005)
Physical Activity Based on Z score, 0=average response	-1.061 (.487)	-1.054 (.412)	-.0348 (.216)	.0001 (.449)	.8265 (.141)	.8539 (.186)
Daily activity Never (1) to Almost every day (5)	2.64 (1.138)	2.44 (1.109)	3.04 (1.119)	3.34 (1.210)	4.90 (.298)	4.94 (.246)
High School Athletics Not at all (1) to Great extent (5)	1.35 (.694)	1.15 (.445)	2.31 (1.315)	2.06 (1.154)	4.87 (.335)	4.69 (.619)
Regular smoker Never (1) to regularly now (5)	1.59 (1.084)	2.05 (1.360)	1.50 (.990)	1.82 (1.204)	1.38 (.816)	1.59 (.978)
Smokeless (last 30 days) Not at all (1) to >1/day (6)	1.10 (.570)	1.10 (.604)	1.07 (.481)	1.12 (.628)	1.12 (.614)	1.16 (.761)
Ever Drink No (1); Yes (2)	1.47 (.499)	1.67 (.471)	1.44 (.496)	1.66 (.476)	1.44 (.497)	1.66 (.473)

Drink in last 30 days None (1) to 40+ (7)	1.36 (.916)	1.70 (1.171)	1.32 (.858)	1.67 (1.116)	1.30 (.805)	1.68 (1.144)
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Analytic Procedures

As described earlier, a conceptual model was created based on the Ecological Model to study adolescent physical activity, tobacco use, and the predictors of these variables (Figure 2). Multiple regression and structural equation modeling (SEM) with maximum likelihood estimation were used to analyze data and model fit. Regression analyses were conducted using SPSS 15.0 software. SEM analyses were conducted using AMOS 7.0 software.

Data analysis was conducted in a series of steps. First, risk and protective factors were analyzed using multiple regression with physical activity as the outcome variable. Next, regression equations were run with tobacco use as the outcome variable. To test for the moderating effects of physical activity, interaction terms were created between physical activity and each of the potential predictors and re-entered into the regression equation as independent variables following the procedures outlined by Baron and Kenny (1986). Next, physical activity was divided into three groups and data was entered into AMOS to test for model fit and differences between groups as outlined by Byrne (2004). Two nested models that differed in equality constraints were tested simultaneously. The first model had no constraints and parameters were allowed to take any value. The second model was more restrictive and required all regression weights to be held constant across groups. The Chi square test, which assesses exact fit with significance indicating failure to fit, was deemed significant if $p < .001$. Chi square

tests can be affected by large sample size and may increase the type I error caused by small differences (Joreskog, 1993). Therefore, model fit was assessed using other indices as well: root mean square error of approximation (RMSEA), the normed fit index (NFI), the comparative fit index (CFI), and relative fit index (RFI). RMSEA values less than .06 and approaching zero, and RFI, CFI, and NFI levels greater than .90 indicate good approximate fit (Bentler, 1990; Browne & Cudeck, 1993; Hu & Bentler, 1999; McDonald & Marsh, 1990). Finally, differences by gender, ethnicity, and physical activity level were tested using Student's t-tests. All results were only considered significant at the $p < .001$ level to account for large sample size. All results are based on weighted data.

Results

Predictors of Physical Activity

Several risk and protective factors emerged as significant predictors of physical activity ($p < .001$) (Table 7). In the eighth grade sample propensity for risk taking, religious identity, television use, work hours, parent support, neighborhood safety, school attachment, academic performance, and school safety predicted physical activity. In the tenth grade sample work, television, and safety were no longer significant predictors. In both eighth grade and tenth grade the strongest predictors of physical activity were religious identity (8th B=.122, 10th B =.096, $p < .001$) and academic performance (8th B =.177, 10th B =.156, $p < .001$). The proposed ecological model explained 11% of the variance in activity in eighth graders and nearly 9% ($R^2=.087$) of the variance in the tenth grade sample.

Table 7-Significant Standardized Regression Weights on Physical Activity

Pathway	8 th Grade			10 th Grade		
	Combined	Male	Female	Combined	Male	Female
Risk Taking	.100	.091	.093	.088	-	.089
Religious ID	.122	.140	.115	.096	-	.154
Work	.071	-	.080	-	-	-
TV	-.055	-	-.077	-	-	-.112
Neighborhood Safety	-.074	-.100	-	-.093	-.069	-.066
Parent Support	.093	.068	.095	.089	.092	-
Parent Presence	-	-	-	-	-	-
School Attachment	.085	.097	.089	.072	-	.098
School Safety	.049	-	-	-	-	-
Academic Performance	.177	.156	.212	.156	.172	.181
Explained Variance (R ²)	.110	.109	.124	.087	.071	.133

All results shown significant at $p < .001$

Predictors of Tobacco Use

When the dependent variable was changed to tobacco use, different predictors emerged ($p < .001$) (Table 8). Attitude toward tobacco, risk taking propensity, work hours, peer pressure to use tobacco, parental presence, school attachment, academic performance, and school safety were significant predictors in eighth graders. Work hours ($B = .121$), peer influence ($B = .101$), and academic performance ($B = -.159$) were the strongest predictors of tobacco use in the eighth grade group. In tenth grade, parental presence dropped from significance. In tenth grade, attitude toward smoking ($B = -.207$), school safety ($B = .133$), and academic performance ($B = -.150$) emerged as the strongest predictors. Physical activity alone did not significantly predict tobacco use. The proposed model explained 19% ($R^2 = .184$) of the variance in tobacco use in eighth graders and 23% ($R^2 = .228$) of the variance in tenth graders.

Table 8-Significant Standardized Regression Weights on Tobacco Use

Pathway	8 th Grade			10 th Grade		
	Combined	Male	Female	Combined	Male	Female
Attitude	-.096	-.105	-.089	-.207	-.218	-.211
Risk Taking	.056	-	.072	.056	-	.128
Perception of Risk	-.097	-.101	-.100	-.097	-.087	-.065
Religious ID	-	-	-.063	-.060	-	-.108
Work	.121	.129	.099	.088	.081	.094
Access	.078	.079	.094	.069	.068	.088
TV	-	-	-	-	-	-.097
Peer Influence	.101	.085	.110	.091	.114	.056
Neighborhood Safety	-	-	-	-.055	-	-
Parent Support	-	-	-	-	-	-
Parent Presence	.058	-	-	-	-	-
School Attachment	-.078	-.067	-.090	-.066	-.072	-
School Safety	.074	-	.086	.133	.131	.073
Academic Performance	-.159	-.175	-.137	-.150	-.126	-.188
Physical Activity	-	-	-	-	-	-.115
Explained Variance (R ²)	.184	.169	.212	.228	.205	.287

All results shown significant at $p < .001$

Moderating Effects of Physical Activity

In the eighth grade sample, the product variable between school attachment and physical activity had a significant effect on tobacco use, indicating that physical activity moderates the effect of school attachment on tobacco use.

In the tenth grade sample no interaction terms were significant at the $p < .001$ level.

However, the parent support and school safety interaction terms were both significant at the $p < .05$ level indicating that these concepts may require more research and examination.

Student's t-test revealed that there were significant differences in eighth graders between sedentary and high physical activity groups ($t(3629)=3.271$, $p < .001$) and sedentary and moderate physical activity groups ($t(2844)=3.215$,

$p < .001$) but no difference between moderate and high groups ($t(3634) = -.489$, $p = .625$). Similar results were found in the tenth grade sample (sedentary v. high $t(3946) = 5.283$, $p < .001$; sedentary v. moderate $t(2995) = 2.696$, $p = .007$; moderate v. high $t(3825) = 1.488$, $p = .137$).

Fit indices for the unconstrained and constrained models for both groups can be found in Table 9. The change in Chi Square related to the change in degrees of freedom is significant between models indicating significant differences between physical activity groups. These results suggest that physical activity may moderate the effects of predictors of tobacco use.

Table 9-Differences Between Physical Activity Groups in Tobacco Model

		Indices	NFI	CFI	RFI	RMSEA, 90% CI, PClose	Comparison ΔX^2 , Δdf , p
8 th Grade	U	$X^2 21.99$, 12df, $p = .038$, $N = 5826$	.997	.998	.905	.013, .003- .021, 1.0	$X^2 175.85$, 50df, $p < .001$
	C	$X^2 197.84$, 62df, $p < .001$, $N = 5826$	.971	.979	.834	.021, .018- .024, 1.0	
10 th Grade	U	$X^2 13.8$, 12df, $p = .312$	.998	1.0	.933	.006, .000- .016, 1.0	$X^2 170.7$, 50df, $p < .001$
	C	$X^2 184.5$, 62df, $p < .001$	.970	.973	.872	.020, .071- .024, 1.0	

U=Unconstrained, C=Regression weights constrained, NFI=Normed Fit Index, RFI=Relative Fit Index, CFI=Comparative Fit Index

Comparisons between squared multiple correlations between physical activity groups reveal interesting results. The variables in the sedentary activity group predicted 23.7% of the variance in tobacco use in eighth grade and 26% of the variance in tenth grade. In the moderate group, 23.9% of the variance in tobacco use in eighth grade and 21.7% of the variance in tenth grade was explained with the model. In the high activity group, 20.1% of the variance was explained in eighth grade and 23% of the variance in the tenth grade group was

explained by the model. These differences may imply a more complex relationship between physical activity and tobacco use than simple moderation.

Differences Between Groups

Gender. Differences in gender were assessed using independent t-tests (Table 10). Significant differences in means were identified in eighth and tenth grade. Significant differences were found in each group. In eighth grade, significant differences were found between males and females in all variables except attitude toward smoking, perception of smoking risk, access to tobacco products, peer influence, and parental presence. In the tenth grade group the only variables that were nonsignificant were access to tobacco, peer influence, parent support, and parental presence.

Table 10-T-tests for Differences Between Genders in Tobacco Model

	8 th Grade					10 th Grade				
	Males		Females		t	Males		Females		t
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Attitude ^a	-.0152	.915	-.0136	.811	-.070	-.0634	.914	.0190	.799	-3.519*
Perception of Risk ^a	-.0344	.908	.0178	.808	-2.258	-.0823	.934	.0587	.786	-5.994*
Risk Taking Propensity ^a	.1378	.928	-.1265	.872	10.340*	.1445	.934	-.1440	.886	11.337*
Religious ID ^a	-.0570	.911	.0895	.874	-5.443*	-.0335	.914	.0993	.882	-4.866*
Work Hours	1.81	1.486	1.50	1.078	9.116*	2.11	1.783	1.82	1.480	6.469*
Access	3.96	1.954	3.95	1.769	.213	4.57	1.413	4.58	1.278	-.306
TV ^a	.0587	.888	-.0384	.883	4.106*	.0698	.889	-.0663	.895	5.609*
Peer Influence	1.22	.616	1.25	.638	-1.457	1.23	.603	1.20	.545	1.986
Neighborhood Safety	1.47	.836	1.67	.861	-9.004*	1.49	.822	1.67	.823	-8.026*
Parent Support ^a	.0411	.761	-.0282	.746	3.040	.0182	.858	-.0296	.848	1.821
Parental Presence	2.80	1.481	2.74	1.495	1.427	2.95	1.443	2.96	1.513	-.160
School Safety ^a	.0861	.751	-.0618	.535	9.73*	.0734	.731	-.0772	.493	8.665*
Academic Performance ^a	-.0911	.621	.0845	.588	-10.85*	-.1071	.623	.1120	.573	-13.47*
School Attachment ^a	-.1201	.846	.1233	.971	-11.14*	-.0702	.838	.0704	.792	-6.345*

Physical Activity ^a	.1001	.838	-.0448	.876	5.893*	.1248	.869	-.1019	.902	9.030*
Tobacco Use ^a	.0971	.951	-.0441	.647	6.035*	.1266	.956	-.0958	.524	10.529*

a=Combined variables using Z scores, * p<.001

For eighth grade girls and boys, and tenth grade girls the strongest predictors of physical activity (Table 7) were religious identity (8th girls B=.115, 8th boys B=.140, 10th girls B=.154) and academic performance (8th girls B=.212, 8th boys B=.156, 10th girls B=.181). In tenth grade boys, however, only three variables were significant: neighborhood environment (B=-.069), perceived parent support (B=.092), and academic performance (B=.172).

When the dependent variable was changed to tobacco use (Table 8), other predictors emerged as significant. In eighth grade girls all variables were significant except for television viewing and neighborhood safety. The strongest predictors of tobacco use were peer influence (B=.110) and academic performance (B=-.137). For eighth grade boys attitude toward tobacco (B=-.105), perception of risk (B=-.101), work hours (B=.129), and academic performance (B=-.175) were the strongest predictors of tobacco use. In tenth grade boys the strongest predictors of use were attitude (B=-.218), peer influence (B=.114), school safety (B=.131), and academic performance (B=-.126). For tenth grade girls all variables were significant predictors of tobacco use except neighborhood safety, parent support, parental presence, and school attachment. The strongest predictors were attitude toward smoking (B=-.211), risk taking behavior (B=.128), religious identity (B=-.108), and academic performance (B=-.188). This was the only group in which physical activity was predictive of tobacco use (B=-.115).

Ethnicity. Independent t-tests in the eighth grade sample revealed significant differences between African American and Caucasian tobacco use ($t(3881)=3.069, p<.001$) but not physical activity ($t(3960)=1.599, p=.110$). African Americans reported more tobacco use than Caucasian adolescents. Furthermore, significant differences in physical activity were observed between Caucasians and Hispanics ($t(3771)=5.119, p<.001$) but not tobacco use ($t(4058)=1.063, p=.288$). Caucasian teens reported more physical activity than their Hispanic counterparts. There were no differences in physical activity ($t(1277)=2.411, p=.016$) or tobacco use ($t(1230)=-2.387, p=.017$) between African American and Hispanic groups.

Similar results were observed in the tenth grade sample. Significant differences were seen between African American and Caucasian groups in physical activity ($t(3846)=3.256, p<.001$) and tobacco use ($t(3981)=7.067, p<.001$). Caucasians reported more physical activity and less tobacco use than African Americans. Differences in physical activity ($t(3962)=5.742, p<.001$) were seen between Caucasian and Hispanic groups while differences in tobacco were not significant ($t(4121)=1.463, p=.143$). Caucasians reported significantly more physical activity than Hispanic adolescents. No differences were observed between African American and Hispanic groups.

Discussion

The purpose of this study was to examine the relationship of physical activity and tobacco use to risk and protective factors in adolescents. A small but significant ($p<.001$) amount of the variance in physical activity was explained by

the proposed conceptual model for eighth grade (11%) and tenth grade (8.7%). Similar variance has been reported in other studies (Ammouri et al., 2007; Garcia et al., 1995). The conceptual model has better fit and explained more of the variance when groups were examined by grade and race/ethnicity. The most variance in physical activity was explained in eighth grade Caucasian students (14.4%). Explained variance for other groups remained significant, but was low (5.7%-13.3%). This low significance may be attributed to the fact that other, non-measured, variables may play a large role in predicting physical activity. Physical activity self-efficacy, intention to be active, and motivation for example may play a significant role in physical activity in adolescents.

A better model fit was obtained when tobacco use was examined. The conceptual model explained a significant amount of variance in tobacco use in both eighth grade (18.4%) and tenth grade (22.8%). While the variance explained is low, analysis by gender and grade produced interesting results. The most explained variance in tobacco use was seen in tenth grade female adolescents (28.7%). These differences may be due to the fact that other non-tested variables play a greater predictive role in adolescent physical activity and tobacco use.

The strongest predictors of tobacco use and physical activity were within the individual and school contexts. The family context variables were not as strong as compared to findings in previous research (Gustafson & Rhodes, 2006; Sanchez et al., 2007; Stucky-Ropp & DiLorenzo, 1993). Religious identity was always positively related to physical activity and negatively related to tobacco use. These results support previous literature that those adolescents who are more

spiritual or participate in an organized religion have better health outcomes (Merrill & Thygeson, 2001; Walker et al., 2007; Wallace Jr. & Forman, 1998). Interestingly, risk taking propensity was positively related to both physical activity and tobacco use. As was expected, adolescents who reported that they like to do risky things to test themselves or that they enjoy doing risky things were more inclined to use tobacco. Similarly, higher risk taking scores predicted higher levels of physical activity. The relationship of risk taking behavior to physical activity was not expected. Although the regression weight for risk taking was low, these significant results hint that adolescents labeled as “risky” have the potential for positive as well as negative health behaviors.

Academic performance was a significant predictor in all models tested. As with previous research, higher academic performance had direct positive effects on physical activity and direct negative effects on tobacco use (Cox et al., 2007; Schmitz et al., 2002). Interestingly, school safety was positively related to the tobacco use and physical activity. Not only did higher school safety have a direct positive effect on physical activity, but it had a direct positive effect on tobacco use. That is to say higher perceived school safety was related to higher levels of physical activity and tobacco use. Higher levels of perceived school safety led adolescents to participate in a variety of behaviors, both risk and protective behaviors. These results indicate that while school safety is a significant variable in adolescent behavior, ensuring or increasing school safety may not have the desired effect on tobacco use.

This is one of the first studies to examine physical activity as a moderator for risky adolescent behavior. While physical activity interaction terms were not significant, differences were observed between physical activity groups. Thus, physical activity was not a true moderator, but did seem to influence tobacco use. The differences between the regression and the SEM multi-group analysis may be due to the higher sensitivity of SEM to distributional assumptions or different handling of missing data. The model explained more of the variance in tobacco use with low physical activity groups (23.9%-25.5%) than with high physical activity groups (18.7%-21.7%). This result further supports the notion that physical activity may influence the effects of risk factors on tobacco use. The nature of this relationship warrants further investigation. Future studies should evaluate the differences between adolescents who are physically active smokers and non-smokers and physically inactive smokers and non-smokers. These results indicate that while physical activity itself may not be a moderator for other risk factors, it remains important when studying tobacco or other negative health behaviors.

This study examined the relationships between risk and protective factors, physical activity, and tobacco use. The Ecological Model of Adolescent Risk Behavior and Youth Outcomes was used to guide the data analysis, although the original the study was not originally designed with this framework. Through cross-sectional analysis of MTF data, support was found for the Ecological Model to guide physical activity and tobacco use research. As explained variance was lower for physical activity, additional variables that may influence adolescent

physical activity should also be explored. Findings indicate that factors from the individual context, the social context, the family context, and the school context have significant effects on physical activity and tobacco use in adolescents.

This study had several limitations. Primarily, the physical activity variable was a combination of two different questions. One question assessed individual exercise participation while the second question addressed the adolescent's participation in group sports or teams at school. Both questions addressed only the frequency of physical activity, missing the important intensity and duration measures that are recommended. Additionally, these two groups have the potential to be different and warrant exploration separately in future studies. Furthermore, the questions that measured physical activity did not ask respondents to quantify the amount of physical activity. Thus, although more than half state that they are physically active nearly every day, it is impossible to determine if adolescents are meeting the recommended guidelines of 30 minutes of activity most days of the week. Finally, adolescents may have over-reported physical activity due to social desirability.

Likewise, the tobacco use variable was the combination of those students who smoked cigarettes and those adolescents who reported smokeless tobacco use. Again, these groups have the potential to be different in nature and warrant individual study in future research. Finally, the model had low explained variance for physical activity, low explained variance for tobacco use, and a relatively small amount of influence of the predictor variables. As the MTF study was not originally intended to be used with the Ecological Model, some variables from the

model are missing from this research. The addition of other variables, such as parental values, school policies, self-efficacy, and role models, may increase the predictive power of the model.

Overall, the Ecological Model of Adolescent Behavior had good fit to the data and explained a small amount of variance in physical activity and tobacco use. Individual and school factors emerged as the strongest predictors of behaviors. Differences were observed between males and females, as well as between racial and ethnic groups. While physical activity did not moderate risk factors in the true sense of the term, differences were observed in tobacco use based on physical activity level. Thus, further research investigating the role and relationship of physical activity with other risk and protective factors is needed.

Chapter 3

Risk and Protective Predictors of Alcohol Use

Introduction

While both alcohol and physical activity have been studied separately, minimal research has examined their relationship and mutual influence. The purpose of this study is to examine predictors of alcohol use and its relationship to physical activity in adolescents from an ecologic perspective. Behaviors and practices that begin in adolescence are cemented in adulthood and may have an impact on the development of chronic disease. Evaluation of one specific risk factor, alcohol use, and its relationship to a protective factor, physical activity, may provide insight into adolescent behavior. Investigation into reasons for participation in physical activity and use of alcohol can aid researchers in the development of interventions aimed at improving adolescent and, ultimately, adult health. Furthermore, identification of predictors of these behaviors and evaluation of potential relationships may provide interesting results.

The United States government identifies specific guidelines and recommendations for adolescent drinking and physical activity in Healthy People 2010 (Services, 2000). Despite these recommendations and guidelines to decrease alcohol use and increase physical activity, the Centers for Disease Control and Prevention still report that the majority (74.3%) of adolescents have

had at least one drink on one or more occasions in the past month (Eaton et al., 2006). Additionally, almost half (43.3%) reported at least one alcoholic drink in the previous month. Moreover, a quarter of adolescents (25.5%) reported drinking five or more alcoholic beverages in a row within the preceding thirty days. While the prevalence of drinking increases with age, an alarming 66.5% of ninth graders have tried alcohol at least once.

In contrast, physical activity rates have declined over the years despite efforts aimed at increasing physical activity among adolescents. In 2005, only 35.8% of adolescents met the current recommendation of physical activity for 60 minutes per day on at least five out of the last seven days (CDC, 2005; Eaton et al., 2006). Furthermore, only 27.8% of girls received the recommended daily physical activity while 43.8% of boys met the guidelines. National recommendations for physical activity continue to increase due to the fact that a study has shown that more people participate in physical activity when recommended levels are higher (Jeffery et al., 2003). However, these increased recommendations have not had the desired effect among adolescents.

Theoretical Framework and Literature Review

The Ecological Model of Adolescent Health Risk Behavior is the organizing framework for this research. The individual context, family context, the social context, school context, and the macro-level environment all play a role in influencing health risk behaviors or positive health behaviors. Previous research on risk and protective factors and predictors of adolescent drinking and exercise behavior will be examined within each context.

Physical Activity and Alcohol Use

Recent research has examined correlations between alcohol use and physical activity. Most research found that as age increases, alcohol use increases, and physical activity declines (Harris et al., 2006; Singh, Mahashwari, Sharma, & Anand, 2006). Therefore, not only are adolescents at increased risk for obesity and cardiovascular disorders related to low physical activity, they are at risk for liver dysfunction and electrolyte imbalance due to the effects of alcohol.

In fact, unhealthy behaviors tend to cluster together. Those individuals that use alcohol usually also smoke, are physically inactive, and eat fewer fruits and vegetables (Poortinga, 2007; Thatcher & Clark, 2006; Tobias, Jackson, Yeh, & Huang, 2007). One study found that if adolescents participated in two risky behaviors, smoking, drinking, or drugs, they had higher rates of psychological distress and depressive symptoms at a two year follow-up (Clark et al., 2007). These behaviors seem to carry over into adulthood, continuing the trend toward obesity and chronic disease. While studies have attempted to explain the relationship between alcohol, physical activity, and other correlates, findings are not congruent between studies and few studies have examined the potential protective effect of physical activity on alcohol use.

One study that examined alcohol use related to physical activity found that an increase in physical activity was positively correlated with an increase in alcohol use (Rockafellow & Savies, 2006). In this study college aged adolescents who were extrinsically motivated to participate in exercise, such as with organized sport teams or encouragement from others, were more likely to drink.

Vickers and colleagues (2004) found similar results specific to binge drinking. Those adolescents who reported binge drinking episodes also reported increased physical activity (OR 2.77, CI 1.07-6.04, $p < .05$) and higher rates of smoking (OR 8.07, CI 4.43-14.71, $p < .05$) than those who were not binge drinkers (Vickers et al., 2004). Thus, alcohol use was associated with both positive and negative health behaviors. While these studies were done with college aged adolescents and cannot be generalized to middle and high-school aged adolescents, results provide another consideration when examining the complex relationship between physical activity and drinking behavior in younger adolescents.

In younger groups, conflicting results are found. When a group of high-schoolers were divided and examined based on their level of sport involvement, athletes tended to participate more in drinking behavior (Rainey, McKeown, Sargent, & Valios, 1996). Rates of general alcohol consumption as well as binge drinking were higher in the athlete groups than the sedentary groups of adolescents. Smoking, however, was lower in athletic groups than sedentary groups indicating that alcohol may have a different relationship with physical activity. In contrast, participation in sports has also been associated with adolescent personality traits that tended to be resistant to alcohol use (Kirkcaldy et al., 2002). Finally, when sports were evaluated in combination with other school activities similar results were found. Students who participated in school activities, with or without sport involvement, used less alcohol than other groups (Harrison & Narayan, 2003). These conflicting results indicate a need for

additional research aimed at identifying the unique relationship between alcohol use and physical activity.

Only two studies examined physical activity as a protective factor for alcohol in adolescents. Project SPORT involved a brief intervention and a wellness brochure given to adolescents specifically aimed decreasing alcohol use while increasing physical activity (Werch et al., 2003). Those who participated in the full intervention (SPORT Plus), consisting of wellness classes, had positive effects for decreased alcohol consumption ($F=4.14$, $p=.04$) and increased physical activity participation ($F=6.64$, $p=.01$) compared to those who received the physical activity only intervention (SPORT). These results, however, were only present at three months and six months post intervention and no results were significant at the 12 month follow up. No significant differences were noted between gender or ethnicity.

The second study, however, found that highly active athletes had the highest rates of alcohol consumption when compared to low active athletes and non athletes (Elder et al., 2000). While males were slightly more likely to drink alcohol than females (OR 1.3, CI 1.14-1.50, $p<.05$), no significant differences were found between ethnicities. Furthermore, no significant findings were observed when different levels of physical activity were examined. These conflicting results indicate a need for further research to evaluate to what extent, if any, physical activity protects adolescents against alcohol use.

Ethnicity has also been identified as a potential risk or protective factor in adolescents. A strong Mexican-American identity was significantly associated

with general alcohol use (AOR=.97) and heavy drinking (AOR=.98) (Love, Yin, Codina, & Zapata, 2006). Those adolescents who had strong Mexican-American identity were more likely to also report higher alcohol use and heavy drinking. Adolescents who are white or Asian have the lowest risk of unhealthy behaviors, while Native Americans have the highest risk (Harris et al., 2006). Whites, however, experience the greatest declines in healthy behaviors when monitored into adulthood (Harris et al., 2006). While interesting, the implications of these results are unclear. Observed differences may be related to genetic, social, and/or environmental influences.

In many studies African American and Hispanic adolescent subgroups report less physical activity (Eaton et al., 2006; Gordon-Larsen et al., 2002; Gordon-Larsen et al., 2000; Harris et al., 2006; Taylor et al., 1999; Whaley & Francis, 2006) and more alcohol use than Caucasian subgroups (Elder et al., 2000; Rodriguez & Audrain-McGovern, 2005; Thorlindsson & Vilhjalmsson, 1991). However, race or ethnicity does not always explain a significant amount of the variance in alcohol use or physical activity (Ammouri et al., 2007; J. Sallis et al., 1999; Trost et al., 1999).

As with physical activity, most often sociodemographic variables account for a small amount of the variance in alcohol behavior or are not significant at all (Elder et al., 2000; Rodriguez & Audrain-McGovern, 2005; Thorlindsson & Vilhjalmsson, 1991). These inconsistencies indicate that additional variables related to race and ethnicity may not have been examined or that ethnicity has effects on distal predictor variables rather than outcome variables. Potential

differences in race and ethnicity continue to warrant further study and investigation. Consistently supported in the literature, however, is the fact that girls participate much less in physical activity than boys (Ammouri et al., 2007; Eaton et al., 2006; Frenn et al., 2003; Trost et al., 2002; Wu et al., 2006). Many researchers have attempted to identify reasons for this discrepancy. Adolescent girls report different motivators and barriers for physical activity than adolescent boys. Lack of motivation, lack of access, gender and weight related bullying, male dominance in physical education classes, and concern for appearance or body shape emerged as individual barriers to physical activity in adolescent girl populations (Allender et al., 2006; Amesty, 2003; Evenson et al., 2007; Gordon-Larsen et al., 2000; Robbins et al., 2003).

Individual Context

The individual context is composed of those biological, psychological, and social attributes that influence individual behavior. In this study, the individual context is conceptualized as attitude toward alcohol use, perception of alcohol risk, risk taking behaviors, religious identity, and individual work behavior.

Adolescent attitudes toward alcohol influence individual alcohol use. These attitudes are also influenced by the perceived risks of alcohol use, risk taking behavior, alcohol use of peers, and the perceived subjective norms. As expected, adolescents who perceive harmful effects from alcohol use are more likely to abstain from drinking (Robinson et al., 2006).

Another individual factor that has a potential effect on both physical activity and drinking is spirituality, religiosity, or belief in a higher power. A

study conducted with adults found that participants who attended church weekly on a regular basis were more likely to be physically active than those participants who went to church less frequently (Merrill & Thygeson, 2001). Other studies, however, have found that personal religiosity or spirituality, not the participation in a formalized religion, is what has an effect on behavior (Walker et al., 2007). Studies in adolescents, while few, have supported this finding. For example, in several studies adolescents who were more religious were less likely to use alcohol (Belcher & Shinitzky, 1998; Merrill & Thygeson, 2001; Walker et al., 2007). It is the individual and personal aspect of religion and spirituality that had significant effects on drinking while the behavior of attending and participating in church was not significant (Walker et al., 2007). Religiosity also had indirect effects on adolescent substance use through good self-control and tolerance for deviance. These findings indicate that religion or spirituality may instill a specific set of social values that make adolescents less likely to use alcohol.

An adolescent's participation in work outside of the home also influences alcohol use. Higher hours of paid work is positively correlated with more alcohol use (Carriere, 2005; Godley et al., 2006; Thorlindsson & Vilhjalmsson, 1991). While not explicitly explored in research studies, time away from parent supervision, access to money, and potential exposure to deviant peers could play a role. The relationship between work and physical activity has not been well studied. Due to the lack of research, further examination into this relationship is needed.

Social Context

The social context, which includes the immediate or built environment and the social environment, has the potential to influence physical activity and alcohol use in a variety of ways. The immediate or built environment is defined as access to parks and alcohol, neighborhood safety, and living surroundings. For example, the social context can effect adolescent behaviors directly or indirectly by influencing attitudes, beliefs, or social norms (Cohen et al., 2000). In this study, the social context consists of access to alcohol, peer influence, television use, and neighborhood safety.

Peer groups play a special role during adolescence. The peer group has influence on cognitive processes as well as behavior through modeling (Zambon et al., 2006). It's influence is so strong in fact that peer behavior has a direct positive effect on drinking behavior (Plotnikoff et al., 2007; Wu & Pender, 2002). Those adolescents who had friends that engaged in risky behaviors, such as drinking, were more likely to participate in risky behaviors (Hawkins et al., 1992; Reininger et al., 2005). In fact, self and peer values regarding risk behaviors explained 29-44% of the variance in aggregate risk (African American females=29%, white females=40%, African American males=28%, white males=44%) (Reininger et al., 2005).

Media and television, another component of the social context, has the potential to have a direct and indirect effect on adolescent behavior. The relationship of alcohol use to television viewing has not been well studied.

There is much support for the relationship between excessive television viewing hours and adolescent obesity due to physical inactivity (Gordon-Larsen et al., 2002; Hancox & Poulton, 2006; Janz et al., 2000; Ochoa et al., 2007). However, recent research reveals that television viewing or computer time in adolescence may be different than in other age groups. One study found that those adolescents who reported high levels of computer and television time also reported high levels of physical activity (Santos et al., 2005). Furthermore, there was no significant difference observed in television time between the active and inactive adolescent groups. These inconsistencies and potential differences between age groups and eras necessitate more research in an effort to explore the changing relationship between television use and physical activity participation.

Family Context

The family context and family interactions are important throughout adolescence. The family context is defined as the social environment in which the adolescent was raised or spends a great deal of time. In this study specifically, the family context is defined as parental support and parental presence.

Family support is related to drinking behavior in adolescents. Perceived support from parents has been shown to have a significant negative effect on drinking and other substance use (Walker et al., 2007). Furthermore, family conflict, poor family bonding, and lack of consistent discipline were associated with higher risk of drinking and substance use (Hawkins et al., 1992; Wang et al., 2005).

School Context

The school is another area that has elicited much research related to physical activity and alcohol use. The school context is conceptualized as the environment and influencing factors in a place of formalized education. In this study, the school context consists of academic performance, school attachment, and school safety.

In general, higher academic achievement and higher grades are associated with lower reports of drinking (Belcher & Shinitzky, 1998; Gau et al., 2007) while academic failure or low academic achievement is correlated with an increased risk of alcohol use (Cox et al., 2007; Hawkins et al., 1992). In fact, in one study, educational performance and beliefs, specifically “homework not being done” and “lower academic standing”, explained nearly 10% of the variance in drinking behavior (Thorlindsson & Vilhjalmsson, 1991). In another study, average grades of a B or better were associated with decreased risk of adolescents engaging in health risk behaviors, such as drinking (Kaplan et al., 2003).

School connectedness or attachment, or participation in the school community and resources, enjoyment of school, and the belief that school is interesting and important, is another concept within the school context that influences adolescent behavior (Wang et al., 2005). Being active in school has been associated with less engagement in risky behaviors (Nelson & Gordon-Larsen, 2006). One study reports that school connectedness has a significant negative direct effect on substance use in both boys and girls (Wang et al., 2005). Participation in school activities, organizations, clubs, and sports deters

adolescent alcohol use. In contrast, school disengagement, or lack of participation, was found to be associated with an increased risk of alcohol use and other risky behaviors (Kliewer & Murrelle, 2007).

In summary, physical activity and alcohol use are important issues in adolescence. The majority of research studies have focused separately on these two phenomena. Few studies, however, have explored the relation of drinking and physical activity with other risk and protective factors. Research that examines the relationship of protective factors and risk behavior often does not include physical activity (Jessor et al., 1995). Physical activity is a health promoting behavior and research needs to examine its relationship with other health protective factors and risk behaviors. Furthermore, ecologic models are seldom used as frameworks for adolescent risk and health behavior.

The purpose of this study is to examine the relationship of physical activity to alcohol use in a nationally representative adolescent population. First, predictors of alcohol use will be explored. Next, physical activity will be tested as a moderator for alcohol use predictors. Differences in alcohol use gender, grade, and race/ethnicity will also be evaluated.

Methods

This study is a secondary analysis using data from a national survey designed to study attitudes, beliefs, and behaviors of adolescents across the country. The Monitoring the Future (MTF) project is a survey of adolescents comprised of a nationally representative sample of the middle and high school

population the United States. Survey procedures are described elsewhere (Johnston et al., 2007).

This study was approved by the University of Michigan Institutional Review Board (UM00019048). Data for this study are from the public database from the Institute for Social Research at the University of Michigan in Ann Arbor. Only data collected from 8th and 10th graders in 2004 on survey form one were utilized to assure consistency of questions across groups. The total sample size was 11,422 (8th grade N=5816, 10th grade N=5606).

As described in Chapter 1, the organizing framework for this study was the Ecological Model of Adolescent Health Risk Behaviors. Although this model has not been extensively explored in physical activity and alcohol use research, many researchers recommend evaluation of the environmental theories and constructs to explore antecedents to health and risk behavior.

Measures

Empirical measures related to these contexts are described. All measures were self-report and utilized three to seven point Likert scales (Table 11). Internal consistency reliability was acceptable for all variables. Some variables were created by taking the mean of several questionnaire items. Reliability coefficients at or near 0.70 are acceptable although higher values indicate higher reliability (Polit, 1996). Physical activity and alcohol use were outcome variables.

Table 11-Construct Items Utilized for Alcohol Model

Context	Construct	Questionnaire Item
Individual	Attitude (8 th grade alpha=.888, 10 th grade alpha=.872)	2 items: -Individuals differ in whether or not they disapprove of people doing certain things. Do you disapprove of people drinking one or two drinks nearly every day? (“Don’t disapprove (1)” to “Strongly disapprove (3)”) - Individuals differ in whether or not they disapprove of people doing certain things. Do you disapprove of people drinking one or two drinks nearly every weekend? (“Don’t disapprove (1)” to “Strongly disapprove (3)”) -Higher scores indicate higher disapproval
	Perception of alcohol risk (8 th grade alpha=.882, 10 th grade alpha=.867)	2 items: - How much do you think that people risk harming themselves (physically or in other ways) if they try one or two drinks of an alcoholic beverage? (“No Risk (1)” to “Great Risk (4)”) - How much do you think people risk harming themselves (physically or in other ways) if they take one or two drinks nearly every day? (“No Risk (1)” to “Great Risk (4)”) -Higher scores indicate greater perceived risk
	Risk taking propensity (8 th grade alpha=.79, 10 th grade alpha=.80)	2 items: - Do you agree or disagree with each of the following: I get a real kick out of doing things that are a little dangerous (“Disagree (1)” to “Agree (5)”) - I like to test myself every now and then by doing something a little risky (“Disagree (1)” to “Agree (5)”) -Higher scores indicate higher risk taking propensity
	Religious identity (8 th grade alpha=.75, 10 th grade alpha=.77)	2 items: -How often do you attend religious services? (“Never (1)” to “About once a week or more (4)”) - How important is religion in your life? (“Not important (1)” to “very important (4)”) -Higher scores indicate higher religious identity/spirituality
	Work	On the average over the school year, how many hours per week do you work in a paid job? (“none (1)” to “more than 30 hours per week (8)”) -Higher scores indicate more hours worked
Social	Access to	How difficult do you think it would be for you to get

	alcohol	each of the following types of drugs, if you wanted some: alcohol? (“Probably impossible (1)” to “Very easy (5)”) <ul style="list-style-type: none"> -Higher scores indicate easier perceived access
	TV (8 th grade alpha=.74, 10 th grade alpha=.76)	2 items: <ul style="list-style-type: none"> - How much TV do you estimate you watch on an average WEEKDAY? (“None (1)” to “Five hours or more (7)”) - How much TV do you estimate you watch on an average WEEKEND? (“None (1)” to “Nine hours or more (7)”) <ul style="list-style-type: none"> -Higher scores indicate more TV hours
	Peer influence	How much pressure do you feel from your friends and schoolmates to drink alcohol? (“None (1)” to “A lot (4)”) <ul style="list-style-type: none"> -Higher scores indicate greater perceived pressure from peers
	Neighborhood Safety	How often do you feel unsafe going to or from school? (“Never (1)” to “Everyday (5)”) <ul style="list-style-type: none"> -Higher scores indicate more unsafe feelings
Family	Parental presence	On average, how much time do you spend after school each day at home with no adult present? (“None or almost none (1)” to “More than five hours (6)”) <ul style="list-style-type: none"> -Higher scores indicate more unsupervised time
	Parental support (8 th grade alpha=.65, 10 th grade alpha=.62)	2 items: <ul style="list-style-type: none"> - How often do your parents check to see if homework is done? (“Never (1)” to “Often (4)”) - How often do your parents help with homework when it is needed? (“Never (1)” to “Often (4)”) <ul style="list-style-type: none"> -Higher scores indicate more perceived parental support
School	School attachment (8 th grade alpha=.77, 10 th grade alpha=.76)	3 items: <ul style="list-style-type: none"> - Thinking back over the past year in school, how often did you enjoy being in school? (“Never (1)” to “Almost always (5)”) - Thinking back over the past year in school, how often did you find your schoolwork interesting? (“Never (1)” to “Almost always (5)”) - Thinking back over the past year in school, how often did you hate being in school? (“Never (1)” to “Almost always (5)”) Item reverse scored) <ul style="list-style-type: none"> -Higher scores indicate greater school attachment
	School safety (8 th grade)	7 items: <ul style="list-style-type: none"> - How often do you feel unsafe when you are at school? (“Never (1)” to “Everyday (5)”)

	alpha=.79, 10 th grade alpha=.78)	<ul style="list-style-type: none"> - During the last 12 months, how often has something of yours (<\$50) been stolen? (“Not at all (1)” to “5 or more times (5)”) - During the last 12 months, how often has something of yours (>\$50) been stolen? (“Not at all (1)” to “5 or more times (5)”) - During the last 12 months, how often has someone deliberately damaged your property? (“Not at all (1)” to “5 or more times (5)”) - Has someone injured you with a weapon? (“Not at all (1)” to “5 or more times (5)”) - Has someone injured you without a weapon? (“Not at all (1)” to “5 or more times (5)”) - Has someone threatened you with injury, but not actually injured you? (“Not at all (1)” to “5 or more times (5)”) <p>-Higher scores indicate feeling less safe in school</p>
	Academic performance (8 th grade alpha=.67, 10 th grade alpha=.66)	<p>6 items:</p> <ul style="list-style-type: none"> - Which of the following best describes your average grade in school this year? (“A (9)” to “D or below (1)”) - Thinking back over the past year in school, how often did you fail to complete or turn in your assignments? (“Never (1)” to “Almost always (5)” Item reverse scored) - Did you ever attend summer school to make up for poor grades or keep from being held back? (“No (1)” to “Yes, three or more summers (4)” Item reverse scored) - Have you ever had to repeat a grade in school? (“No (1)” to “Yes, two or more times (3)” Item reverse scored) - Have you ever been suspended or expelled from school? (“No (1)” to “Yes, two or more times (3)” Item reverse scored) - How often do you try to do your best work in school? (“Never (1)” to “Almost always (5)”) <p>-Higher scores indicate greater academic performance</p>
Physical Activity	(8 th grade alpha=.68, 10 th grade alpha=.75)	<p>2 items:</p> <ul style="list-style-type: none"> - To what extent have you participated in the following school activities during this school year: athletic teams? (“Not at all (1)” to “Great (5)”) - How often do you actively participate in sports, athletics, or exercise? (“Never (1)” to “Almost every day (5)”)

		-Higher scores indicate more physical activity
Alcohol use	(8 th grade alpha=.836, 10 th grade alpha=.889)	7 items: - Have you ever drunk alcohol? (“Never (1)” to “Regularly now (5)”) - How many drinks have you had in the last 30 days? (“None (1)” to “40 or more (7)”) - How many times have you been drunk in your lifetime? (“Never (1)” to “40+ (7)”) - How many times have you been drunk in the last 30 days? (“None (1)” to “40+ (7)”) - How many times have you had five or more drinks in a row in the last 2 weeks? (“None (1)” to “10+ (6)”) - How many times have you had a drink in the last 12 months? (“None (1)” to “40+ (7)”) -How many times have you been drunk in the last 12 months? (“None (1)” to “40+ (7)”) -Higher score indicates greater alcohol use

Physical activity was measured with two questions that quantified the extent to which adolescents participated in exercise and organized school sports. A combined general physical activity score was created by taking the mean of these two questions. Physical activity was then transformed into sedentary and high groups based on natural breaks in the data and national guidelines and recommendations. The sedentary group consisted of those adolescents who stated that they engaged in physical activity never to a few times per year or did not participate in school athletics. Participants were classified in the high physical activity group if they stated that they were active nearly every day or if they participated in school athletics a considerable amount or a great extent. Alcohol use was measured by seven questions that asked adolescents if they have ever drunk alcohol or binge drank and the frequency of use in the past 30 days and 12 months. The mean score of these seven questions was used to create an Alcohol

Use variable. Alcohol users are defined as those adolescents who drank any amount of alcohol or who self-identified as a “regular user.”

Five constructs were measured in the individual context. Perception of tobacco risk, attitude toward alcohol, spirituality or religion, adolescent paid work, and risk taking propensity are included in this model. Four concepts were included within the social context. Access to alcohol, television viewing, peer influence to use alcohol, and neighborhood safety were examined in the model. Two concepts were included from the family context. Parental presence in the home and parental support of adolescent were evaluated. Finally, school context was measured by three factors. Academic performance, school attachment, and school safety were evaluated.

Sample Characteristics

Of the total 11,426 adolescents who were used for this study, approximately 51% were 8th grade students at the time of survey (N=5826) and 49% were 10th grade students (N=5606) (Table 12). In the eighth grade sample males and females were equally represented (males=48.9%, females=48.3%, missing=2.8%). The majority of the sample was Caucasian (59.9%), followed by Hispanic (14.7%), and African-American (11.1%). More than three quarters of the sample lived in a city or town (75.7%). Almost half of the students were enrolled at a college preparatory program or general high school (31.6%, 17.4% respectively). The majority of the students did not work for money outside of the home (65.9%). Twenty nine percent of 8th graders did not participate in organized athletics, while over half (55.2%) report that they get some form of daily exercise.

Table 12-Demographic Information for Alcohol Model

	8 th Grade (N=5826) % (n)	10 th Grade (N=5606) % (n)
Gender		
Male	48.9 (2847)	46.9 (2627)
Female	48.3 (2816)	50.3 (2814)
Race/Ethnicity		
Caucasian	59.9 (3491)	61.3 (3434)
African American	11.1 (646)	12.6 (705)
Hispanic	14.7 (859)	15.6 (876)
Other/Missing	14.2 (829)	10.4 (585)
Environment		
Farm	5.4 (317)	3.8 (213)
Country	17.7 (997)	16.7 (937)
City/Town	75.7 (4410)	77.6 (4345)
Type of School		
College Prep	31.6 (1841)	47.3 (2647)
General HS	17.4 (1012)	23.8 (1330)
Voc/Tech	4.1 (237)	4.7 (264)
Other/Don't Know	42.9 (2499)	21.8 (1219)
Paid Job		
No Work	65.9 (3838)	63.4 (3548)
Work <5 hr/wk	18.3 (1065)	12.0 (670)

The tenth grade sample had similar demographics. Most adolescents were Caucasian (61.3 %), followed by Hispanic (15.6%) and African Americans (12.6%). Nearly 80% (77.6%) lived in cities or towns. Most of the students were enrolled in a college preparatory program (47.3%) or general high school (23.8%). Most students did not have a job outside of the home (63.4%) or worked five or less hours per week (12.0%). Thirty five percent of students participated in organized athletics, while half (50.4%) reported that they get some form of daily exercise. Alcohol responses are presented in Table 13. Full descriptive statistics of predictor variables and outcome variables can be found in Table 5. Descriptive statistics of physical activity groups can be found in Table 6.

Table 13-Alcohol Use

	8 th Grade (N=5826) % (n)	10 th Grade (N=5606) % (n)
Ever drink	42.9 (2500)	63.4 (3549)
Drunk		
1-2 times/life	10.1 (589)	14.5 (811)
3-5 times	2.9 (169)	8.5 (476)
6-9 times	1.7 (101)	5.3 (298)
Drink last 12 months		
1-2 times	16.8 (976)	17.2 (964)
3-5 times	8.2 (478)	12.5 (701)
6-9 times	4.5 (264)	10.3 (577)
Drunk last 12 months		
1-2 times	7.9 (463)	15.7 (880)
3-5 times	2.2 (127)	7.1 (398)
6-9 times	1.5 (85)	3.6 (204)
5+ drinks in last 2 wks	4.3 (252)	8.3 (461)
1 time	3.4 (195)	5.3 (299)
2 times	2.0 (116)	4.7 (103)
3-5 times		
Drink in last 30 days	10.9 (636)	10.5 (1036)
1-2 times	3.6 (210)	8.6 (481)
3-5 times		

Analytic Procedures

As described earlier, a conceptual model was created based on the Ecological Model to study adolescent physical activity, tobacco use, and the predictors of these variables. Multiple regression and structural equation modeling (SEM) with maximum likelihood estimation were used to analyze data and model fit. Regression analyses were conducted using SPSS 15.0 software. SEM analyses were conducted using AMOS 7.0 software.

Data analysis was conducted in a series of steps. First, regression analyses were run with alcohol use as the outcome variable. To test for the moderating

effects of physical activity, interaction terms were created between physical activity and each of the potential predictors and re-entered into the regression equation as independent variables following the procedures outlined by Baron and Kenny (1986). Next, physical activity was divided into two groups (sedentary and high physical activity) and data was entered into AMOS to test for model fit and differences between groups as outlined by Byrne (2004). Two nested models that differed in equality constraints were tested simultaneously. The first model had no constraints and parameters were allowed to take any value. The second model was more restrictive and required all regression weights to be held constant across groups. The Chi square test, which assesses exact fit with significance indicating failure to fit, was deemed significant if $p < .001$. Chi square tests can be affected by large sample size and may increase the type I error caused by small differences (Joreskog, 1993). Therefore, model fit was assessed using other indices as well: root mean square error of approximation (RMSEA), the normed fit index (NFI), the comparative fit index (CFI), and the relative fit index (RFI). RMSEA values less than .06 and approaching zero and NFI, CFI, and RFI values greater than .90 indicate good model fit (Bentler, 1990; Browne & Cudeck, 1993; Hu & Bentler, 1999; McDonald & Marsh, 1990). Finally, differences by gender and ethnicity were assessed using Student's t-tests. Results were considered significant at the $p < .001$ level. Data were weighted for all analyses.

Results

Predictors of Alcohol Use

In the eighth grade sample attitude toward alcohol, propensity for taking risks, perceived risk of alcohol, work hours, access to alcohol, peer pressure to drink, parental presence, parental support, school safety, and academic performance emerged as significant predictors of alcohol use ($p < .001$) (Table 14). In the tenth grade sample the above predictors remained significant, in addition to religious identity, television use, and physical activity. The strongest predictors for both eighth and tenth grades were attitude toward alcohol (8th $B = -.115$, 10th $B = -.255$), perceived risk of alcohol use (8th $B = -.170$, 10th $B = -.163$), and academic performance (8th $B = -.162$, 10th $B = -.149$). Physical activity was not a significant predictor of alcohol use in the eighth grade sample. In the tenth grade sample, however, physical activity was a small, but significant, predictor of alcohol use in boys ($B = .096$) and girls ($B = .133$). In the eighth grade sample the model explained nearly 28% ($R^2 = .278$) of the variance in alcohol use and for tenth graders, nearly a third ($R^2 = .333$) of the variance was explained.

Table 14-Significant Standardized Regression Weights on Alcohol Use

Pathway	8 th Grade			10 th Grade		
	Combined	Male	Female	Combined	Male	Female
Attitude	-.115	-.078	-.175	-.255	-.261	-.261
Risk Taking	.096	.061	.155	.120	.101	.145
Perception of Risk	-.170	-.197	-.118	-.163	-.144	-.182
Religious ID	-	-	-	-.089	-.089	-.083
Work	.091	.129	.060	.079	.093	.073
Access	.098	.100	.100	.088	.088	.077
TV	-	-	-	-.055	-	-.068
Peer Influence	.094	.078	.091	.052	.070	-
Neighborhood Safety	-	-	-	-	-	-
Parent Support	-.075	-.096	-	-	-	-
Parent Presence	.081	.087	-.071	-	-	-
School Attachment	-.078	-	-	-.051	-	-
School Safety	.111	.124	.109	.061	.066	-
Academic Performance	-.162	-.159	-.173	-.149	-.161	-.139
Physical Activity	-	-	-	-	.096	.133
Explained Variance (R ²)	.278	.264	.330	.333	.315	.357

All results shown significant at $p < .001$

Moderating Effects of Physical Activity

In the eighth grade sample the combination variable between physical activity and television use had a significant effect on alcohol use indicating that physical activity moderates the effect of television watching on alcohol use ($t(28)=4.096, p < .001$). No interaction terms were significant at the $p < .001$ level in the tenth grade sample. However, the parental support and physical activity interaction item was significant at the $p < .05$ level ($t(28)=-2.061, p = .039$) in the eighth grade group and the school safety and physical activity interaction term had significant effects in the tenth grade group ($t(28)=2.933, p = .003$) indicating that these terms may require further examination and study.

Student's t-tests revealed no significant differences in alcohol use between low and high physical activity groups (8th grade $t(3266)=-1.962, p = .05$, 10th grade

$t(3771)=-.671, p=.503$). Fit indices for the unconstrained and constrained models for both groups can be found in Table 15. The change in Chi Square relative to the change in degrees of freedom is significant between models in both eighth and tenth grades indicating significant differences between groups. These results suggest that physical activity may moderate predictors of alcohol use.

Table 15-Differences Between Physical Activity Groups, Alcohol Model

		Indices	NFI	CFI	RFI	RMSEA, 90% CI, P Close	Comparison $\Delta X^2, \Delta df, p$
8 th Grade	U	$X^2 15.54, 8df,$ $p=.049, N=5826$	.997	.999	.917	.017, .001- .029, 1.0	$X^2 121.59,$ 25df, $p<.001$
	C	$X^2 137.13, 33df,$ $p<.001, N=5826$	.976	.981	.823	.031, .026- .036, 1.0	
10 th Grade	U	$X^2 26.698, 8df,$ $p=.001$	.996	.997	.882	.024, .014- .034, 1.0	$X^2 115.17,$ 25df, $p<.001$
	C	$X^2 141.865, 33df,$ $p<.001$	.979	.983	.848	.029, .024- .034, 1.0	

U=Unconstrained, C=Regression weights constrained, NFI=Normed Fit Index, RFI=Relative Fit Index, CFI=Comparative Fit Index

Comparisons between squared multiple correlations between physical activity groups reveal interesting results. The variables in the sedentary activity group predicted 25.8% of the variance in alcohol use in eighth grade and 31.3% of the variance in tenth grade. In the high activity group, 34.3% of the variance was explained in eighth grade and 38% of the variance in the tenth grade group was explained by the model. These differences may imply a more complex relationship between physical activity and alcohol use than simple moderation.

Differences Between Groups

Gender Independent t-tests identified significant differences in means in both eighth grade and tenth grade (Table 16). Significant differences were found in each group. In eighth grade, significant differences were found between males and females in all variables except attitude toward alcohol, perception of alcohol risk, access to alcohol products, peer influence, and parental presence. In the tenth grade group the only variables that were nonsignificant were attitude, access to alcohol, peer influence, parent support, and parental presence. In eighth grade boys reported more physical activity than girls ($t(4869)=5.893, p<.001$), but no significant differences were observed in alcohol use. In the tenth grade sample boys continued to be more physically active ($t(5228)=9.030, p<.001$), but also reported more alcohol use than girls ($t(4995)=3.787, p<.001$).

Table 16-T-tests for Difference Between Gender, Alcohol Model

	8 th Grade					10 th Grade				
	Males		Females		t	Males		Females		t
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Attitude ^a	-.0026	.961	-.0332	.796	1.254	-.0406	.925	.0912	.792	-2.548
Perception of Risk ^a	-.0161	.965	.0003	.815	-.681	-.0823	.934	.0587	.786	-5.994*
Risk Taking Propensity ^a	.1378	.928	-.1265	.872	10.340*	-.0491	.972	.0507	.782	-4.152*
Religious ID ^a	-.0570	.911	.0895	.874	-5.443*	-.0335	.914	.0993	.882	-4.866*
Work Hours	1.81	1.48	1.50	1.07	9.116*	2.11	1.78	1.82	1.480	6.469*
Access	4.11	1.82	4.00	1.68	2.103	4.61	1.29	4.64	1.143	-.772
TV ^a	.0587	.888	-.0384	.883	4.106*	.0698	.889	-.0663	.895	5.609*
Peer Influence	1.35	.741	1.40	.778	-2.234	1.57	.867	1.59	.860	-.893
Neighborhood Safety	1.47	.836	1.67	.861	-9.004*	1.49	.822	1.67	.823	-8.026*
Parent Support ^a	.0411	.761	-.0282	.746	3.040	.0182	.858	-.0296	.848	1.821
Parental Presence	2.80	1.48	2.74	1.49	1.427	2.95	1.44	2.96	1.513	-.160
School Safety ^a	.0861	.751	-.0618	.535	9.73*	.0734	.731	-.0772	.493	8.665*
Academic Perf. ^a	-.0911	.621	.0845	.588	-10.85*	-.1071	.623	.1120	.573	-13.47*
School	-.1201	.846	.1233	.971	-11.14*	-.0702	.838	.0704	.792	-6.345*

Attachment ^a										
Physical Activity ^a	.1001	.838	-.0448	.876	5.893*	.1248	.869	-.1019	.902	9.030*
Alcohol Use ^a	.5050	.734	.4999	.684	.267	.5796	.726	.5069	.634	3.787*

a=Combined variables using Z scores, * p<.001

Several variables were significant predictors of alcohol use although the amount of influence was small (Table 14). In eighth grade girls' attitude, risk taking, perceived alcohol risk, work hours, access to substance, peer pressure to drink, parent presence, school safety, and academic performance were significant predictors of alcohol use. The strongest predictors of alcohol use were attitude (B=-.175), risk taking (B=.155), and academic performance (B=-.173). For eighth grade boys perception of alcohol risk (B=-.197), work hours (B=.129), school safety (B=.124), and academic performance (B=-.159) were the strongest predictors of alcohol use. In tenth grade girls the strongest predictors of use were attitude (B=-.261), risk taking (B=.145), alcohol risk (B=-.182), and academic performance (B=-.139). For tenth grade boys all variables were significant predictors of tobacco use except television viewing, neighborhood safety, and school attachment. The strongest predictors were attitude toward alcohol (B=-.261), perceived risk of alcohol (B=-.144), and academic performance (B=-.161). This was the only group in which physical activity was predictive of tobacco use (B=.096).

The proposed model explained 26% of the variance ($R^2=.264$) of alcohol use in eighth grade boys. In tenth grade boys 31% of the variance was explained ($R^2=.315$). In eighth grade girls 33% of the variance ($R^2=.330$) in alcohol use was explained by the model while nearly 36% of the variance ($R^2=.357$) was explained by the model in tenth grade girls.

Ethnicity Independent t-tests in the eighth grade sample revealed no significant differences in alcohol use between Caucasian and African American respondents. Hispanics reported more alcohol use ($t(4050)=-4.327, p<.001$) than Caucasians and African Americans ($t(3981)=-3.0909, p<.001$). Similar results were observed in the tenth grade sample. Whites reported more drinking than African Americans ($t(3820)=6.729, p<.001$). Likewise, Hispanics reported more alcohol use than African Americans ($t(1220)=-7.320, p<.001$). No significant differences in alcohol use were seen between Caucasians and Hispanics.

In eighth grade African Americans, the proposed model explained nearly 27% ($R^2=.268$) of the variance in alcohol use. In tenth grade African Americans 25% ($R^2=.254$) of the variance was explained. In Hispanics, the model predicted 28% ($R^2=.281$) of the variance in eighth graders and 35% ($R^2=.355$) of the variance in tenth graders. In Caucasian groups the model accounted for 31% ($R^2=.316$) of the variance in the eighth grade group and 36% ($R^2=.360$) of the variance in the tenth grade group.

Discussion

The purpose of this study was to examine the relationship of physical activity and alcohol use to risk and protective factors in adolescents. The conceptual model explained a significant amount of variance in alcohol use in both eighth grade (28.1%) and tenth grade (33.2%). While the variance explained is low to moderate, analysis by gender and grade produced interesting results. The most explained variance in alcohol use was seen in tenth grade Caucasian adolescents (36%), tenth grade Hispanics (35.5%) and tenth grade females

(35.7%). These differences may be due to the fact that other non-tested variables play a greater predictive role in adolescent physical activity and alcohol use.

The strongest predictors of alcohol use were within the individual and school contexts. The family context variables were not as strong as compared to findings in previous research (Gustafson & Rhodes, 2006; Sanchez et al., 2007; Stucky-Ropp & DiLorenzo, 1993). Religious identity was always positively related to physical activity and negatively related to alcohol use. These results support previous literature that those adolescents who are more spiritual or participate in an organized religion have better health outcomes (Merrill & Thygeson, 2001; Walker et al., 2007; Wallace Jr. & Forman, 1998).

Interestingly, risk taking propensity was positively related to both physical activity and alcohol use in every group. As was expected, adolescents who reported that they like to do risky things to test themselves or that they enjoy doing risky things were more inclined to drink alcohol. Similarly, higher risk taking scores predicted higher levels of physical activity. The relationship of risk taking behavior to physical activity, although very small, was not expected. These results hint that adolescents labeled as “risky” have the potential for positive health outcomes as well as negative behaviors.

Academic performance was a significant predictor in all models tested. As with previous research, higher academic performance had direct positive effects on physical activity and direct negative effects on alcohol use (Cox et al., 2007; Schmitz et al., 2002). School safety was consistently positively related to alcohol use and physical activity, regardless of group. Not only did higher school

safety have a direct positive effect on physical activity, but it had a direct positive effect on alcohol use. That is to say higher perceived school safety was related to higher levels of physical activity and alcohol use. Higher levels of perceived school safety led adolescents to participate in a variety of behaviors, both risk and protective. These results indicate that while school safety is a significant variable in adolescent behavior, ensuring or increasing school safety may not have the desired effect on negative behaviors.

This is one of the first studies to examine physical activity as a moderator for risky adolescent behavior. While only one physical activity interaction term was significant, differences were observed in alcohol use between sedentary and high physical activity groups. Thus, physical activity was not a true moderator, but did seem to influence alcohol use. The model explained more of the variance in alcohol use with high physical activity groups (34.3-38.0%) than with low physical activity groups (25.8-31.3%). This result contradicts the notion that physical activity may play some protective role against alcohol use. Furthermore, physical activity positively predicted alcohol use in tenth grade boys and girls. Those adolescents who reported more physical activity also reported more alcohol use. The nature of this relationship warrants further investigation. One possible explanation may be a social or peer influence to drink alcohol on sports teams. Future studies should evaluate the differences between adolescents who are physically active drinkers and non-drinkers and physically inactive drinkers and non-drinkers.

This study examined the relationships between risk and protective factors, physical activity, and alcohol use. The Ecological Model of Adolescent Risk Behavior and Youth Outcomes was used to guide the data analysis, although the original the study was not originally designed with this framework. Through cross-sectional analysis of MTF data, support was found for the Ecological Model to guide physical activity and alcohol use research. Findings indicate that factors from the individual context, the social context, the family context, and the school context have significant effects on physical activity and alcohol use in adolescents.

This study had several limitations. Primarily, the measure of physical activity consisted of only two questions, no objective measure was taken to confirm reports. The addition of further questions or a physical activity diary or recall would confirm and strengthen the physical activity measure. Secondly, the family support measure in this study does not match other research. Family support was based on three questions that looked at parental presence after school and support for and assistance with homework. While this does identify a type of family support, it is not specific to physical activity or alcohol use. Future studies should use measures of support specific to the outcome measure studied. Next, alcohol use was comprised of those adolescents who drank regularly and those who participated in binge drinking. These may be two distinct groups that warrant further independent study. In addition, while nested models did improve when constraints were removed, most fit indices were positive with appropriate significance levels. Large sample size could have played a role in the significance

of several findings. Finally, the MTF data was not originally intended to be used with the Ecological Model. The addition of other variables from the Ecological Model, such as socioeconomic status, parental views, role models, and self-efficacy, may increase the explained variance and predictability of the model.

Overall, the Ecological Model of Adolescent Behavior had good fit to the data and explained a small amount of variance in physical activity and a small to moderate amount of the variance in alcohol use. Individual and school factors emerged as the strongest predictors of behaviors. Differences were observed between males and females, as well as between racial and ethnic groups. While physical activity did not moderate risk factors in the true definition of the term, differences were observed in alcohol use based on physical activity level. Thus, further research investigating the role and relationship of physical activity with other risk and protective factors is needed.

Chapter 4

Environmental Predictors of Physical Activity in Adolescents

Physical activity has many documented benefits. Not only does it decrease the risks for cardiovascular disease and obesity, it also promotes psychological well being. Unfortunately, however, most Americans do not get the recommended amounts of physical activity. Adolescents, in particular, are of special interest as habits that are created in this time are likely to carry over into adulthood.

Past research has focused on perceived barriers and benefits of physical activity, gender and ethnic differences, and creative interventions aimed at increasing adolescent physical activity. While this research provides valuable information, the lack of physical activity among adolescents continues to be a concern in the United States. Several political agendas and initiatives, such as Healthy People 2000 and 2010, have specifically identified goals related to increasing physical activity in adolescent populations. Examination of different related environmental factors may provide insight into this ongoing issue.

The adolescent's perception of his or her personal environment is rarely mentioned in physical activity studies, even though it may be a barrier, risk, or protective factor. Little research has explored the perceived or personal environment of adolescents in relation to their reported physical activity (Babey et

al., 2007; J. Sallis et al., 2003). In addition, studies have failed to adequately study the relationship of the physical and social environment to physical activity specific to adolescents. These variables have the potential to act as risk or protective factors in adolescents. Furthermore, they have the potential to be unique among adolescents, as a function of age and gender. Utilizing an ecologic perspective, the purpose of this study is to examine the adolescent's perceived environmental factors as they relate to physical activity. Specifically, this study aims to identify perceived environmental predictors of physical activity in adolescents over time.

Theoretical Framework and Literature Review

The Ecological Model of Adolescent Health Risk Behavior is the organizing framework for this research. The individual, family, social, and school contexts, and the macro-level environment all play a role in influencing health risk behaviors or positive health behaviors. The focus here is on the perceived environmental influences on physical activity within the macro-level environment (time period), social context (neighborhood safety, peer influence, urban v. rural, television), family context (parental presence and support), and school context (school safety, attachment or connectedness, type of high school program).

Macro-level Environment

The macro-level environment is defined as political influences, historical events, and macro-level economics that influence adolescent's behavior. Political realities, youth laws and policies, macro-level economics, and historical events are part of the macro-level environment and have the potential to affect

adolescents related to health risk and health behavior outcomes (Arthur et al., 2002). Studies have examined the influence of research on practice and policy, yet few have examined groups to see if the desired outcomes of policy changes and initiatives were met (Chaloupka & Johnston, 2007). In this research three time points, 1992, 1999, and 2004, are conceptualized as a proxy for historical events and political initiatives. For example, Healthy People 2000 goals and initiatives may have had an influence on 1999 data while the revised goals of Healthy People 2010 may have potentially had an impact on the 2004 data. Additionally, over historical time several phenomena have the potential to interact with each other and influence physical activity (Brown, Schulenberg, Bachman, O'Malley, & Johnston, 2001).

Social Context

The social context, which includes the immediate or built environment as well as the social environment, has the potential to influence physical activity in a variety of ways. The immediate or built environment is defined as the neighborhood surroundings or make up, neighborhood safety, and access to parks. For example, the social context can effect adolescent behaviors directly or indirectly by influencing attitudes, beliefs, or social norms (Cohen et al., 2000). In this study, the social context consists of immediate built environment or locale, neighborhood safety, peer influence, and television use.

Opportunities for physical activity are different for those who live on a farm, in rural communities, and in towns or cities. Minimal research, however, has differentiated these environments in terms of influence on physical activity.

In one study of rural communities across three southern states distance from recreational facility (AOR 1.8, CI 1.3-2.4, $p=.05$), feeling unsafe related to crime (AOR 2.1, CI 1.5-2.9, $p=.05$), and feeling unsafe related to traffic (AOR 1.7, CI 1.2-2.3, $p=.05$) were all associated with lower reported levels of physical activity (Boehmer, Lovegreen, Haire-Joshu, & Brownson, 2006). Furthermore, participants reported feeling that their community was unpleasant and did not lend well to being physically active. In fact, the aesthetic value of the community seems to have an impact on reported physical activity. In one group, children were more likely to report being physically active if they felt that their community had aesthetic value (OR 1.302, $p=.05$) (Mota, Almeida, Santos, & Ribeiro, 2005).

In one study, urban adolescent females reported physical activity was comparable to the national average (30.5% reported regular exercise) (Saxena et al., 2002). The study examined social variables but did not examine specific environmental correlates. Those girls who reported friends who were regular exercisers (OR 4.72), being involved with at least one sports team (OR 3.59), and trying to lose weight (OR 2.92) were more likely to report higher levels of physical activity among urban adolescent females. While this study yields interesting findings, no significance level was reported. Thus, implications are difficult to interpret.

In a Canadian study, no significant differences were found in physical activity between urban and rural adolescent groups (Loucaides, Plotnikoff, & Bercovitz, 2007). Again, no specific environmental variables were examined in the study. Significant differences were seen in physical activity between genders

with girls participating less in both urban and rural settings. Psychological variables, such as perception of physical ability, self-efficacy, and interest in group activities, explained the largest variance in both rural and urban settings. Ultimately, more similarities than differences were exhibited between urban and rural groups. In the United States, town size has been related to different barriers to physical activity (Badland & Schofield, 2006). Study participants who lived in smaller towns reported barriers to physical activity that were related to distance, infrastructure, and lack of access. Participants who lived in larger towns and cities, however, reported barriers that were more personal in nature such as time and desire.

More consistently studied in the literature, however, is the influence of safety on physical activity. Lower rates of crime have been associated with lower body mass indexes (Evenson et al., 2007) and higher reports of physical activity in adolescents (Granner, Sharpe, Hutto, Wilcox, & Addy, 2007). In one study, girls who felt that the neighborhood was unsafe were more likely to be inactive (OR 0.60, $p=.05$) than those who felt safe (Mota, Gomes, Almeida, Ribeiro, & Santos, 2007). Safety concerns related to traffic, that is feeling that neighborhoods were too busy to participate in physical activity, were noted as barriers to exercise and activity in two studies (Boehmer et al., 2006; King et al., 2006). In contrast, one study reported that perceptions of neighborhood violence had no significant effect on physical activity (Kuo, Voorhees, Haythornthwaite, & Young, 2007) while another reported that perceived neighborhood safety did not have any direct or indirect effects on physical activity (Motl, Dishman, Saunders,

Dowda, & Pate, 2007). The different findings in these studies may be due to differences in environmental context, urban or rural areas, or differences in adolescents' perceptions.

More studied is the relationship of peer influence to adolescent behavior. Peer groups play a special role during adolescence. The peer group has influence on cognitive processes as well as behavior through modeling (Zambon et al., 2006). It's influence is so strong in fact that peer behavior has a direct positive effect on physical activity behavior (Wu & Pender, 2002). In fact, adolescents who had friends who participated in physical activity were much more likely to be active themselves (O.R. 4.72, C.I 1.58-14.14, $p < .05$) than those whose peer group was not active (Saxena et al., 2002). Similarly, self and peer values about risky behavior explained the most variance in aggregate risk score for risky behavior (African American females=29%, White females=40%, African American males=28%, White males=44%) (Hawkins et al., 1992; Reininger et al., 2005).

Media and television, another component of the social context, has the potential to have a direct and indirect effect on adolescent behavior. There is much support for the relationship between excessive television viewing hours and adolescent obesity due to physical inactivity (Gordon-Larsen et al., 2002; Hancox & Poulton, 2006; Janz et al., 2000; Ochoa et al., 2007). However, recent research reveals that television viewing or computer time in adolescence may be different than in other age groups. One study found that those adolescents who reported high levels of computer and television time also reported high levels of physical activity (Santos et al., 2005). Furthermore, there was no significant difference

observed in television time between the active and inactive adolescent groups. These inconsistencies and potential differences between age groups and eras necessitate more research in an effort to explore the changing relationship between television use and physical activity participation.

Family Context

The family context and family interactions are important throughout adolescence. The family context is defined as the social environment in which the adolescent was raised or spends a great deal of time. In this study specifically, the family context is defined as general parental support and parental presence.

Family and parent support has been shown to significantly affect physical activity (Dowda et al., 2007; Heitzler et al., 2006; Raudsepp, 2006). Higher levels of perceived family support by adolescents have a significant positive correlation with physical activity (Gustafson & Rhodes, 2006; Neumark-Sztainer, Story, Hannan, Tharp et al., 2003; Simantov et al., 2000). In one study family support explained six to ten percent of the variance in physical activity depending on age of the adolescent (J. Sallis et al., 1999).

School Context

The school is another area that has elicited much research related to physical activity. The school context is conceptualized as the environment and influencing factors in a place of formalized education. In this study, the school context consists of school connectedness or attachment, high school program, competition for grades, and school safety.

Academic achievement has been associated with higher levels of physical activity. Schmitz and colleagues found that a higher academic rank was predictive of higher levels of physical activity (Schmitz et al., 2002).

Adolescents who reported high levels of exercise also reported higher grade point averages than those with lower reported exercise in another study (Field et al., 2001). Additionally, those adolescents who were involved in a team sport had higher grades than were expected as well as an increased probability of attending college, more enjoyment of school, and more connectedness to school (Eccles & Barber, 1999; Field et al., 2001).

School connectedness or attachment, or participation in the school community and resources, enjoyment of school, and the belief that school is interesting and important, is another concept within the school context that influences adolescent behavior (Wang et al., 2005). Being active in school has been associated with less engagement in risky behaviors. In contrast, school disengagement, or lack of participation, was found to be associated with an increased risk of tobacco use and other risky behaviors (Kliewer & Murrelle, 2007).

In summary, physical inactivity in adolescent groups is an ongoing problem. Most research has focused on individual barriers to physical activity. Studies have recommended examining adolescent behavior, and physical activity in particular, from an ecologic or environmental perspective, however the research is limited in this area. Environmental factors, particularly as they are perceived by the adolescent, have the potential to influence behavior and physical

activity. The purpose of this study is to examine environmental variables influence on physical activity in adolescents in 1992, 1999, and 2004 utilizing the Ecological Model for Adolescent Health and Risk Behavior. Differences in gender and ethnicity will be explored. Significant predictors will be compared across years.

Methods

This study is a secondary analysis using data from a national survey designed to study attitudes, beliefs, and behaviors of adolescents across the country. The Monitoring the Future (MTF) project is a survey of adolescents comprised of a nationally representative sample of the middle and high school population the United States. Survey procedures are described elsewhere (Johnston et al., 2007). A multi-stage random sampling procedure was used in each year. Similar sampling methodology and questions were used in each year. Sampling weights are used during all analysis to correct for unequal selection probabilities in sampling.

This study was approved by the University of Michigan Institutional Review Board (HUM00019048). Data for this study are from the public database from the Institute for Social Research at the University of Michigan in Ann Arbor. Only data collected from 8th and 10th graders on survey form one were utilized to assure consistency across grades and years. Eighth and tenth grade data was used from 1992, 1999, and 2004. The total sample size was 38,770 (1992: 8th=9501, 10th=7483; 1999: 8th= 5745, 10th=4609; 2004: 8th= 5826, 10th=5606).

As described in Chapter 1, the organizing framework for this study was the Ecological Model of Adolescent Health Risk Behaviors. Although this model has not been extensively explored in physical activity and tobacco use research, many researchers recommend evaluation of the environmental theories and constructs to explore antecedents to health and risk behavior.

Measures

Empirical measures related to these contexts are described. All measures were self-report and utilized three to seven point Likert scales (Table 17). Some questionnaire items were combined to form new variables using the mean of the variables. Internal consistency reliability was acceptable for all variables. Reliability coefficients at or near 0.70 are acceptable although higher values indicate higher reliability (Polit, 1996). Physical activity was the outcome variable.

Physical activity was measured with two questions that quantified the extent to which adolescents participated in exercise and organized school sports. As seen in Table 17, the social context was operationalized by four constructs. Location of respondent (farm, country, town/city), television viewing (two questions), peer influence (two questions), and neighborhood safety were examined in the model. The family context included two constructs. Parental presence in the home and parental support (five questions) of the adolescent were evaluated. Finally, four constructs were included within the school context. Type of high school program (college preparatory, general, vocational/technical,

other/don't know), competition for grades, school attachment (three questions), and school safety (seven questions) were evaluated.

Table 17-Summary of Construct Items

Context	Construct	Questionnaire Item
Social	Location	Where do you live now? (Farm (1), Country (2), City/Town (3))
	TV (8 th grade alpha=.74, 10 th grade alpha=.76)	2 items: - How much TV do you estimate you watch on an average WEEKDAY? (“None (1)” to “Five hours or more (7)”) - How much TV do you estimate you watch on an average WEEKEND? (“None (1)” to “Nine hours or more (7)”) -Higher scores indicate more TV use
	Peer Pressure (8 th grade alpha=.81, 10 th grade alpha=.73)	2 items: -How much pressure do you feel from your friends and schoolmates to smoke cigarettes/drink alcohol? (“None (1)” to “A lot (4)”) -Higher scores indicate greater pressure from peers
	Neighborhood Safety	How often do you feel unsafe going to or from school? (“Never (1)” to “Everyday (5)”) -Higher scores indicate lower feelings of safety
Family	Parental presence	On average, how much time do you spend after school each day at home with no adult present? (“None or almost none (1)” to “More than five hours (6)”) -Higher scores indicate more unsupervised time
	Parental support (8 th grade alpha=.778, 10 th grade alpha=.61)	5 items: - How often do your parents check to see if homework is done? (“Never (1)” to “Often (5)”) - How often do your parents help with homework when it is needed? (“Never (1)” to “Often (5)”) -Limit TV (“Never (1)” to “Often (5)”) -Limit time going out with friends (“Never (1)” to “Often (5)”) -Able to talk problems out with parent (“Never (1)” to “Often (5)”) -Higher scores indicate greater perceived parental support
School	School attachment (8 th grade)	3 items: - Thinking back over the past year in school, how often did you enjoy being in school? (“Never (1)” to

	alpha=.77, 10 th grade alpha=.76)	<p>“Almost always (5)”</p> <ul style="list-style-type: none"> - Thinking back over the past year in school, how often did you find your schoolwork interesting? (“Never (1)” to “Almost always (5)”) - Thinking back over the past year in school, how often did you hate being in school? (“Never (1)” to “Almost always (5)” Item reverse scored) <p>-Higher scores indicate higher school attachment</p>
	School safety (8 th grade alpha=.78, 10 th grade alpha=.77)	<p>7 items:</p> <ul style="list-style-type: none"> - How often do you feel unsafe when you are at school? (“Never (1)” to “Everyday (5)”) - During the last 12 months, how often has something of yours (<\$50) been stolen? (“Not at all (1)” to “5 or more times (5)”) - During the last 12 months, how often has something of yours (>\$50) been stolen? (“Not at all (1)” to “5 or more times (5)”) - During the last 12 months, how often has someone deliberately damaged your property? (“Not at all (1)” to “5 or more times (5)”) - Has someone injured you with a weapon? (“Not at all (1)” to “5 or more times (5)”) - Has someone injured you without a weapon? (“Not at all (1)” to “5 or more times (5)”) - Has someone threatened you with injury, but not actually injured you? (“Not at all (1)” to “5 or more times (5)”) <p>-Higher scores indicate feeling less safe at school</p>
	High School Program	-Which of the following best describes your present (or expected) high school program? (College prep (1), general (2), vocational/tech/commercial (3), don’t know (4))
	Competition for grades	-How much competition for grades is there among students at your school? (“None (1)” to “a great deal (5)”) <p>-Higher scores indicate more competition</p>
Physical Activity	(8 th grade alpha=.68, 10 th grade alpha=.75)	<p>2 items:</p> <ul style="list-style-type: none"> - To what extent have you participated in the following school activities during this school year: athletic teams? (“Not at all (1)” to “Great (5)”) - How often do you actively participate in sports, athletics, or exercise? (“Never (1)” to “Almost every day (5)”) <p>-Higher scores indicate more physical activity</p>

Sample Characteristics

Similar demographics and sample characteristics were observed between years and grades (Table 16). Males and females were nearly equal at all time points and there were no significant differences observed between years or grades (Chi Square=13.043, 5df, $p=.023$). The majority of the sample was Caucasian, fitting with the national representation, however there were differences observed between years (Chi Square=57.577, 5df, $p<.001$). Proportions of African Americans and Caucasians did not remain constant in each dataset. Gender and ethnic data in the MTF dataset are sampled to reflect the national ethnic representation. Data are weighted during analysis to account for sampling bias. Approximately three quarters of adolescents reported living in cities or towns. Most reported attending a college preparatory or general high school. Finally, only half at each time point reported physical activity on nearly every day of the week. Most means seemed to remain constant across years (Table 19).

Table 18- Demographic Information, Environment Model

		1992		1999		2004	
		8 th Grade N=9501 % (n)	10 th Grade N=7843 % (n)	8 th Grade N=5745 % (n)	10 th Grade N=4609 % (n)	8 th Grade N=5826 % (n)	10 th Grade N=5606 % (n)
Gender	Male	47.5 (4510)	47.7 (3568)	45.4 (2607)	45.9 (2115)	48.9 (2847)	47.7 (2675)
	Female	49.2 (4673)	50.1 (3749)	50.3 (2887)	50.9 (2347)	48.3 (2816)	49.5 (2776)
Ethnicity	African American	12.5 (1187)	14.2 (1063)	14.8 (849)	12.0 (554)	11.1 (646)	12.3 (692)
	White	57.5 (5462)	65.9 (4934)	54.5 (3128)	63.4 (2923)	59.9 (3491)	60.6 (3397)
Location	Farm	3.9 (369)	3.6 (268)	4.3 (245)	3.8 (175)	5.4 (317)	3.4 (191)
	Country	16.5 (1566)	20.2 (1512)	17.6 (1013)	20.0 (922)	17.1 (997)	15.4 (866)
	City/Town	77.0 (7313)	74.5 (5578)	75.4 (4333)	74.2 (3420)	75.7 (4410)	79.2 (4442)
HS Program	College prep	32.6 (3093)	50.6 (3786)	31.2 (1790)	47.2 (2174)	31.6 (1841)	49.5 (2777)
	General	17.0 (1619)	22.2 (1662)	17.9 (1027)	22.9 (1056)	17.4 (1012)	22.8 (1276)
	Voc-tech	6.2 (592)	8.7 (653)	5.5 (315)	6.7 (310)	4.1 (237)	4.6 (256)
Daily Activity	Never	6.0 (569)	7.6 (567)	6.0 (345)	7.8 (361)	6.6 (386)	8.9 (497)
	Few/year	10.2 (970)	11.6 (864)	10.5 (603)	11.1 (513)	9.5 (552)	11.3 (635)
	1-2/month	9.0 (856)	8.1 (608)	9.4 (542)	9.2 (423)	7.9 (461)	9.1 (510)
	1/week	19.2 (1825)	18.5 (1382)	21.1 (1209)	18.7 (861)	20.0 (1166)	18.9 (1061)
	Nearly daily	54.9 (5216)	53.8 (4024)	52.2 (3001)	52.6 (2426)	55.2 (3217)	50.9 (2854)

Table 19- Descriptive Statistics, 1992, 1999, and 2004

Variable	1992		1999		2004	
	8 th Grade	10 th Grade	8 th Grade	10 th Grade	8 th Grade	10 th Grade
Location Farm (1), Country (2), City/Town (3)	2.751 (.517)	2.722 (.523)	2.731 (.533)	2.718 (.529)	2.715 (.561)	2.773 (.495)
TV Based on Z scores, 0=average response	.0000 (.874)	.0007 (.884)	-.0008 (.883)	-.0004 (.888)	.0002 (.890)	.0006 (.898)
Peer Pressure Based on Z score, 0=average response	.0001 (.825)	.0001 (.779)	.0010 (.852)	.0002 (.819)	-.0020 (.909)	-.0005 (.873)
Neighborhood Safety Never feel unsafe (1) to Everyday (5)	1.630 (.896)	1.546 (.807)	1.691 (.937)	1.596 (.857)	1.733 (.905)	1.596 (.850)
Parent Presence No time alone (1) to 5+ hrs alone (5)	2.998 (1.562)	3.013 (1.531)	3.009 (1.515)	3.061 (1.516)	2.768 (1.493)	2.944 (1.477)
Parent Support Based on Z score, 0=average response	.0001 (.602)	-.0002 (.583)	-.0003 (.634)	.0000 (.618)	-.0002 (.639)	-.0005 (.625)
School Safety Based on Z score, 0=average response	-.0038 (.626)	1.393 (.488)	-.0003 (.635)	-.0003 (.626)	-.0004 (.645)	-.0011 (.632)
HS Program Academic/College prep (1), General (2), Voc/tech/comm. (3), don't know (4)	2.538 (1.325)	1.904 (1.123)	2.577 (1.323)	2.013 (1.186)	2.607 (1.339)	1.966 (1.186)
Competition for Grades None (1) to Great deal (5)	2.849 (1.207)	3.034 (1.131)	2.785 (1.164)	2.965 (1.159)	2.685 (1.219)	2.926 (1.188)
School Attachment Based on Z score, 0=average response	.0030 (.586)	.0039 (.572)	.0027 (.593)	.0065 (.585)	.0006 (.586)	.0037 (.577)
Physical Activity Based on Z score, 0=average response	.0121 (.858)	.0120 (.879)	.0174 (.861)	.0083 (.877)	.0104 (.864)	.0078 (.892)

Analytic Procedures

As described earlier, a conceptual model was created based on the Ecological Model to study adolescent physical activity and perceived environmental predictors (Figure 4). Multiple regression and model fit analyses with maximum likelihood estimation were used to analyze data. Regression analyses were conducted using SPSS 15.0 software. Model fit analyses were conducted using AMOS 7.0 software.

Data analysis was conducted in a series of steps. First, significant predictors were identified using multiple regression with physical activity as the outcome variable for 1992, 1999, and 2004. Next, each year was entered into AMOS to test for model fit and differences between groups. The Chi square test, which assesses exact fit with significance indicating failure to fit, was deemed significant if $p < .001$. Chi square tests can be affected by large sample size and may increase the type I error caused by small differences (Joreskog, 1993). Therefore, model fit was assessed using other indices as well: root mean square error of approximation (RMSEA), the normed fit index (NFI), the comparative fit index (CFI), and the relative fit index (RFI). RMSEA values less than .06 and approaching zero and NFI, CFI, and RFI values greater than .90 indicate good model fit (Bentler, 1990; Browne & Cudeck, 1993; Hu & Bentler, 1999; McDonald & Marsh, 1990). Finally, differences between years, gender, and ethnicity (African American, Caucasian) were tested using Student's t-tests and multi-group invariance analysis in Amos Graphics as outlined by Byrne (2004).

Two nested models that differed in equality constraints were tested simultaneously. The first model had no constraints and parameters were allowed to take any value. The second model was more restrictive and required all regression weights to be held constant across groups. All results were only considered significant at the $p < .001$ level. Data were weighted for all analyses.

Results

Predictors of Physical Activity

Several variables from the Ecological Model were significant predictors of physical activity over time (Table 20). Unsafe neighborhoods had a significant negative influence on physical activity in all years (1992: 8th grade $B = -.097$, 10th grade $B = -.138$; 1999 8th grade $B = -.054$, 10th grade $B = -.096$; 2004 8th grade $B = -.100$, 10th grade $B = -.130$; all values significant at $p < .001$). General parent support had a positive influence on physical activity across all years and grades (1992 8th grade $B = .099$, 10th grade $B = .138$; 1999 8th grade $B = .120$, 10th grade $B = .102$; 2004 8th grade $B = .154$, 10th grade $B = .151$). All school factors, except school safety, were significant in all models tested. Students in college preparatory or general high schools were more likely to report higher levels of physical activity than those in vocational or technological schools. Students who perceived higher competition for grades were more likely to report higher levels of physical activity across years. School attachment was the strongest perceived environmental predictor of physical activity in all years and grades (1992 8th grade $B = .313$, 10th grade $B = .203$; 1999 8th grade $B = .261$, 10th grade $B = .230$; 2004 8th grade $B = .240$, 10th grade $B = .095$; all values significant at $p < .001$).

Location or type of environment (urban v. rural) was significant in only 8th graders in 1999 (B=-.093, p<.001). Television use had a small, but significant, negative influence on physical activity in most groups (1992 8th grade B=-.036, 10th grade B=-.044; 1999 8th grade B=-.054, 10th grade B=NS, 2004 8th grade B=-.078, 10th grade B=-.130; p<.001). Peer pressure was only significant in 8th graders in 1999 (B=.056, p<.001) and 10th graders in 2004 (B=.074, p<.001). School safety was only significant in the 1992 8th grade group (B=.059, p<.001). Parental presence was not significant in any group tested. The Ecological Model explained only a small amount of the variance in physical activity in all models (R²=9.5-10.7%).

Table 20- Standardized Regression Weights on Physical Activity

Pathway	1992		1999		2004	
	8 th Grade	10 th Grade	8 th Grade	10 th Grade	8 th Grade	10 th Grade
Location	-	-	-.093	-	-	-
TV	-.036	-.044	-.054	-	-.078	-.051
Peer Pressure	-	-	.056	-	-	.074
Neighborhood Safety	-.097	-.138	-.054	-.096	-.100	-.130
Parent Presence	-	-	-	-	-	-
Parent Support	.099	.138	.120	.102	.154	.151
School Safety	.059	-	-	-	-	-
HS Program	-.064	-.117	-.058	-.098	-.038	-.125
Competition for Grades	.045	.053	.095	.070	.079	.086
School Attachment	.313	.203	.261	.230	.240	.095
Explained Variance (R ²)	.105	.097	.107	.095	.103	.102

All results shown significant at p<.001

Differences Between Groups

When groups were examined by gender and ethnicity several significant findings emerged (Table 21). Television use was significantly different between

genders and ethnicities. In all groups, across years, males and African Americans reported more television use than girls or Caucasian groups. Perceived neighborhood safety was significantly different between groups. Females reported feeling more unsafe than males and African Americans stated they felt less safe than Caucasian groups. School attachment had significant differences between groups. In all years boys reported significantly less school attachment than girls and African Americans reported higher levels of school attachment than Caucasians. Boys reported significantly more physical activity than girls across years and grades.

Table 21 T-tests for Differences Between Groups, Environment Model

	1992				1999				2004					
	8 th		10 th		8 th		10 th		8 th		10 th			
	G	E	G	E	G	E	G	E	G	E	G	E		
Location	-4.00	-9.96	-4.43	-12.58	--	-11.20	--	-	8.38	--	-	8.78	--	-10.77
TV	10.56	-20.16	8.83	-23.53	7.67	-19.71	6.63	-	4.10	-	5.65	-	-20.24	
Peer Pressure	--	--	--	--	--	--	3.32	--	--	--	--	--	4.33	
N ^h ood Safety	-	-12.36	-	-10.00	-	-8.77	-	-	-	-	-	-	-7.34	
Parent Presence	10.23	--	11.20	--	8.58	--	8.40	11.9	9.00	8.61	8.05	--	-7.66	
Parent Support	--	-5.94	--	-3.90	--	-5.67	--	-	6.13	--	--	--	-7.66	
School Safety	--	--	--	--	--	3.75	--	--	--	--	--	--	--	
HS Program	13.33	--	10.93	--	5.89	--	7.58	-	7.96	-	8.87	-	-3.87	
Compet. for Grades	--	-7.52	--	-15.51	--	-5.14	4.42	-	4.86	3.39	3.19	-	-4.82	
School Attach.	--	--	--	--	--	--	--	--	--	5.73	3.40	--	--	
Physical Activity	-	-4.24	-	-5.68	-	-3.59	-	--	-	-	-	-	-4.28	
	19.30	--	17.38	--	16.6	--	14.2	--	17.6	3.19	17.0	--	-4.28	
	13.12	--	15.31	3.237	6.53	--	9.68	--	5.89	--	9.09	--	--	

G=Gender Groups (male v. female), E=Ethnicity Groups (white v. black), all results shown significant at p<.001

Differences Between Years

Multi-group analysis was used to test for differences between years.

Regression weights were constrained across years to test for differences (Table 22). The change in Chi Square relative to the change in degrees of freedom was not significant in the tenth grade comparison, indicating that there were no significant differences in regression weights across years. However, the change in Chi square relative to the change in degrees of freedom was significant in the eighth grade sample indicating that there were significant differences in regression weights between 1992, 1999, and 2004.

Table 22 Differences Across Years (1992, 1999, 2004)

		Indices	NFI	CFI	RFI	RMSEA, 90% CI, PClose	Comparison ΔX^2 , Δdf , p
8 th	U	$X^2=0$, 0df	1.0	1.0	1.0	.000	
	C	$X^2=64.396$, 20df, p<.001	.993	.995	.943	.012, .008-.015, 1.0	$X^2=64.396$, 20df, p<.001
10 th	U	$X^2=0$, 0df	1.0	1.0	1.0	.000	
	C	$X^2=34.860$, 20df, p=.021	.996	.998	.963	.007, .003-.011, 1.0	$X^2=34.860$, 20df, p=.021

U=Unconstrained, C=Regression weights constrained, NFI=normed fit index, CFI=comparative fit index, RFI=relative fit index

Discussion

The purpose of this study was to examine the predictors of physical activity at three different time points. A small but significant (p<.001) amount of the variance in physical activity was explained by the proposed conceptual model for eighth grade and tenth grade at each time point (9.5-10.7%). Similar variance has been reported in other studies (Ammouri et al., 2007; Garcia et al., 1995),

however, better explained variance has been found with different theoretical models (Dishman et al., 2002; Motl et al., 2007). While the explained variance is low, interesting results emerged examining significant predictors of physical activity.

Perceived neighborhood safety was a significant predictor in all groups. In each year higher levels of feeling unsafe had direct negative effects on physical activity. The more unsafe an adolescent felt, the lower physical activity was reported. Furthermore, girls reported higher levels of feeling unsafe in the neighborhood than boys in all years and grades. Although it has been proposed that neighborhood safety influences physical activity (Evenson et al., 2007; Granner et al., 2007; Mota et al., 2007), no studies have specifically examined the differences in perceived safety between boys and girls. Safety at the school was only significant in eighth grade groups in 1992 and 2004, however, significant differences existed between boys and girls in most groups. Boys reported feeling unsafe at school more than girls. These gender differences in safety have not been sufficiently studied in previous studies and warrant further investigation. One possible explanation for these differences is a feeling of protection at school by school officials in girl groups.

Parental support was a variable that was significant in all groups in each year. Although the variable did not measure parental support specific to physical activity, it always had a direct positive effect on physical activity. These results support previous research that emphasizes the importance of parental support for physical activity (Gustafson & Rhodes, 2006; Neumark-Sztainer, Story, Hannan,

Tharp et al., 2003). However, these results indicate that general support for the adolescent may also play an important role in supporting healthy behavior in adolescents.

Television use was a significant predictor of physical activity in most groups. When significant, higher number of television hours were associated with lower reported physical activity. While regression weights were low, these data support previous studies that identify the negative influence of television use on physical activity (Gordon-Larsen et al., 2002; Hancox & Poulton, 2006). The fact that television was not significant in all groups may indicate that a more complex relationship exists between television use and physical activity.

School attachment was a significant predictor of physical activity in every group and year. Higher levels of school attachment were associated with higher reported levels of physical activity. Interestingly, school attachment was the most significant predictor of physical activity in the model in all groups except for the tenth grade 2004 group. This positive relationship was not surprising as higher levels of school connectedness have been associated with positive behaviors in previous studies (Eccles & Barber, 1999).

In all groups and years boys reported more physical activity than girls. These results add to the literature that indicate a need for gender based interventions to increase physical activity. However, no significant differences in physical activity were found between African American and Caucasian groups. This is in direct contrast to some literature that state that minority groups report less physical activity than whites (Eaton et al., 2006; Gordon-Larsen et al., 2002).

African American groups reported feeling more unsafe in neighborhoods and schools and higher hours of television viewing. These results may indicate that the significant differences in physical activity found in other studies may be related to access issues or personal barriers rather than race.

The similar explained variances in physical activity over the years leads this author to believe that political initiatives aimed at increasing physical activity in adolescents, specifically Healthy People 2000 and 2010, have not had the desired effect. Additionally, the decrease of required physical activity in schools over the last decade may have had an impact on the amount of reported physical activity. Although the significant predictors may change over time, the amount of variance explained by environmental factors based on the Ecological Model of Adolescent Health and Risk Behavior is not significantly different. Furthermore, no significant differences were observed in physical activity level between years. The percentage of eighth and tenth graders that never participated in physical activity (8th grade: 1992=6%, 1999=6%, 2004=6.6%; 10th grade: 1992=7.6%, 1999=7.8%, 2004=8.9%) or participated on a near daily basis (8th grade: 1992=54%, 1999=52.2%, 2004=55.2%; 10th grade: 1992=53.8%, 1999=52.6%, 2004=50.9%) remained constant across years. Although more than half consistently report being active nearly every day, the survey instrument did not have participants quantify the amount or intensity of physical activity. Thus, adolescents continue to report low levels of physical activity that may not meet the recommendations. Future studies should continue to examine environmental factors associated with physical activity in adolescents.

This study had several limitations. Primarily, comparisons were made across years with cross sectional data. Years were significantly different in ethnic make up. Although results were weighted to account for these differences, future studies should aim to compare similar groups and longitudinal data for more meaningful implications. In addition, the physical activity variable was a combination of two different questions and only measured frequency, not intensity or duration of physical activity. One question assessed individual exercise participation while the second question addressed the adolescent's participation in group sports or teams at school. These two groups have the potential to be different and warrant exploration separately in future studies. Furthermore, the questions that measured physical activity did not ask respondents to quantify the amount of physical activity. Thus, although many state that they are physically active nearly every day, it is impossible to determine if adolescents are meeting the recommended guidelines of 30 minutes of activity most days of the week. Future studies should attempt to examine physical activity in accordance with past research utilizing frequency, duration, and intensity.

Furthermore, the conceptualization of parent support was based on general support and was not specific to physical activity like many previous studies. Future studies should examine the potential benefits of general, as well as physical activity specific, parent support. Additionally, as data are from a public dataset not originally intended to be used with an Ecological Model, not all environmental variables from the proposed framework were included in the study. Future prospective studies could include more variables based on the Ecologic

Model, such as parental values, self-efficacy, low-risk friend group, and school policies, and provide stronger results and support for examination of physical activity from an environmental perspective. Finally, the sample size is very large and yields many significant results. Conservative measures were taken to account for this large sample size. Results were only considered significant at p levels less than .001 and results were weighted for all analyses.

This study examined the predictors of physical activity over time. The Ecological Model of Adolescent Risk Behavior and Youth Outcomes was used to guide the data analysis, although the original the study was not originally designed with this framework. Through cross-sectional analysis of MTF data, support was found for further physical activity research utilizing the full Ecological Model. Findings indicate that neighborhood and school safety, parental support, and school attachment have significant effects on physical activity in adolescents over time. The Ecological Model of Adolescent Behavior explained a small, but significant, amount of variance in physical activity. Environmental factors emerged as significant predictors of adolescent physical activity. Differences were observed between males and females, as well as between racial and ethnic groups.

Chapter 5

Conclusion

Physical activity and exercise has significantly declined over the last several decades, with the most concerning decreases observed in childhood and adolescent populations (CDC, 2005). Previous physical activity research has focused primarily on barriers to physical activity and behavioral modification via individualized and group interventions yet rates of physical activity do not increase. Thus, research in adolescent physical activity barriers, predictors, and associated factors from an ecologic or environmental framework is needed. Additionally, research aimed at identification of non-traditional positive effects of physical activity is lacking. There has been limited exploration of physical activity as a protective factor for risky behaviors such as tobacco and alcohol use. It is not clear if physical activity is associated with specific risk or protective factors or risk behavior. Furthermore, physical activity itself is rarely considered in risk behavior research.

The purpose of these studies was to examine three separate, but related, research questions that explored the relationship of physical activity to specific risk and protective factors and health risk and promotion behaviors in adolescents. The first study examined the relationship between risk and protective factors, tobacco use, and physical activity. The second study examined risk and

protective predictors of alcohol use and the relationship to physical activity.

Finally, the third study explored adolescent's perceived environmental factors as predictors of physical inactivity and protective factors of physical activity and evaluated the identified predictors over time in three different years.

Ecological Model of Adolescent Health and Risk Behaviors

The guiding framework for all three studies was the Ecological Model of Adolescent Health Risk Behaviors. As stated previously, this model proposes that the macro-level environment, social context, school context, family context, peer context, and individual context interact with each other to influence adolescent behavior and produce either health risk behaviors or youth health outcomes.

Within each context risk and protective factors interact and ultimately influence adolescent behavior. Variables were included from the individual, social, family, and school contexts to test for potential influence on risk behaviors, specifically tobacco use and alcohol use, and the health behavior of physical activity.

Furthermore, physical activity, while not included in the Ecologic Model, was added as a protective factor and tested for a possible relationship with risky behavior.

Five factors were included from the individual context. Attitude toward the substance, risk taking propensity, perception of the risk of the substance, religious identity, and work hours were evaluated for influence. In the social context ease of access to get the substance, television viewing time, peer influence to participate in risky behavior, and neighborhood safety were studied. The family context included general parent support as perceived by the adolescent and

parental presence or time spent alone after school. The school context consisted of school attachment or connectedness, perceived school safety, academic performance, and type of high school program.

Predictors of Risk and Health Behavior

The first two studies used an ecological framework to test for predictors of substance use, specifically tobacco and alcohol. Physical activity was tested as a direct predictor as well as a moderator of the effects of other variables on tobacco and alcohol use. The third study examined physical activity over time. Perceived environmental factors, such as neighborhood safety, perceived parental support, and school safety, were examined in three different years to assess for potential differences between years and groups and changes over time.

Tobacco and Alcohol Use

Several variables were significant ($p < .001$) predictors of self-reported tobacco and alcohol use in adolescents. The strongest predictors were within the individual and school contexts in both the eighth grade and tenth grade groups. Attitude toward the substance, perception of substance risk, and academic performance were the strongest predictors of both tobacco and alcohol use. Adolescents who thought that using these substances was bad or risky were less likely to engage in the behavior. Furthermore, adolescents with higher academic performance were less likely to use both tobacco and alcohol. These findings support previous studies that identify the influence of attitude and perception of

risk on tobacco and alcohol use (Gustafson & Rhodes, 2006; Robinson et al., 2006; Smith et al., 2007; Stucky-Ropp & DiLorenzo, 1993).

Likewise, ease of access positively predicted tobacco and alcohol use. Those adolescents who felt that it was relatively easy to get the substance were more likely to respond as a user. Finally, within the individual context, similar to other studies higher number of work hours were associated with higher reported use of tobacco and alcohol (Carriere, 2005; Godley et al., 2006; Thorlindsson & Vilhjalmsson, 1991).

Interestingly, the family context did not produce strong significant predictors of tobacco use or alcohol use. In previous studies family variables played a strong role in adolescent behavior, specifically tobacco and alcohol use (Gustafson & Rhodes, 2006; Sanchez et al., 2007). While family context variables were significant predictors of alcohol use in the eighth grade groups, no family concepts were significant in the tenth grade group. Within the school context academic performance had a significant negative influence on tobacco and alcohol use similar to previous research (Cox et al., 2007). Those students with higher grades and academic achievement were less likely to report use of tobacco or alcohol.

The factors in the Ecological Model explained a small to moderate amount of the variance in tobacco use. The model explained 18.4% of the variance in tobacco use in the eighth grade group and 22.8% of the variance in the tenth grade group. The Ecological Model had better fit to the data and explained more of the

variance in alcohol use. The model explained 27.8% of the variance in alcohol use in the 8th grade group and 33.3% of the variance in the tenth grade group.

Results from the studies indicate that the individual context and school context variables are important to consider and study when examining adolescent risk behavior. Although tobacco use and alcohol use are different substances and behaviors, similar predictors emerged. Adolescent attitude toward the substance, perception of risk, work behavior, and academic performance should be closely examined when exploring substance use from an ecological perspective.

Effects of Physical Activity on Risk Behavior

Physical activity was a significant predictor of substance use in three groups tested. Physical activity had a direct negative effect on tobacco use in the tenth grade female group. Higher levels of reported physical activity predicted lower levels of tobacco use. When alcohol was the outcome variable, however, physical activity had direct positive effects on alcohol use in both male and female tenth grade groups. Higher levels of physical activity predicted higher report of alcohol use. This discrepancy indicates that physical activity may have both a positive and negative effect on other adolescent behaviors.

The study of physical activity's relationship to predictors of risk behavior terms yielded non-significant results. When tobacco use was the outcome variable only school attachment was statistically moderated by physical activity. Furthermore, this result was present only in the eighth grade sample. That is to say the negative effects of lower school attachment were lessened when the adolescent reported higher levels of physical activity. In the tenth grade sample

the parental support and school safety interaction terms only approached significance ($p=.05$).

In relation to alcohol use, physical activity changed the effects of television use on physical activity. This relationship was only observed in the eighth grade group. Those adolescents who reported higher levels of television use had lower levels of reported alcohol use when they also reported high levels of physical activity. That is to say that physical activity lessened the negative effect of high television hours on alcohol use.

Parental support and school safety approached significance ($p=.003-.05$) when both tobacco and alcohol use were examined. Thus, while the exact relationship of physical activity to low parental support or school safety cannot be determined from this study, more research is needed to identify the possible positive influence of physical activity on these risk factors.

The model explained more variance in tobacco use for sedentary physical activity groups than high physical activity groups. Significant differences existed between these two distinct groups ($t(3629)=3.271, p<.001$ in 8th grade, $t(3946)=5.283, p<.001$ in 10th grade). Multiple group analysis confirmed significant differences in predictors of tobacco use between physical activity levels. Adolescents who were more physically active were also less likely to report tobacco use. Conversely, no differences in physical activity levels were observed when alcohol use was the outcome variable. In fact, physical activity level did not seem to have an impact on adolescents' reported use of alcohol.

Thus, the relationship of physical activity to adolescent tobacco and alcohol use behavior is complex and cannot be easily explained.

Predictors of Physical Activity Over Time

In the third study, the purpose was to determine predictors of physical activity at three time points to identify potential changes over time. Only five environmental variables were significant predictors of physical activity in each year. Neighborhood safety, parent support, high-school program, competition for grades, and school attachment were significant predictors in both eighth and tenth grade groups in 1992, 1999, and 2004. Those adolescents who reported feeling safer in their neighborhoods also reported more physical activity. Furthermore, girls reported feeling significantly more unsafe than boys. While these findings support previous literature that cites the importance of safe surroundings to facilitate exercise (Evenson et al., 2007; Granner et al., 2007) no studies have adequately examined the potential gender differences in the influence of perceived neighborhood safety on physical activity.

Higher levels of parental support were associated with higher levels of reported physical activity. Previous studies have found that parental support for physical activity has a positive influence on reported exercise (Gustafson & Rhodes, 2006; Neumark-Sztainer, Story, Hannan, Tharp et al., 2003). In this study, however, parental support was general, not specific to physical activity. These results indicate that living in a perceived supportive environment may have positive effects on health behaviors even if the type of support is not specific to the behavior.

High school program, competition for grades, and school attachment were all significantly predictive of physical activity. Those students who were in general or college preparatory high schools reported more physical activity than those who were in vocational and technological schools. Higher levels of perceived competition within the school were predictive of higher levels of reported physical activity. Likewise, those adolescents who reported higher levels of school connectedness or attachment were more likely to report higher levels of physical activity. These results support other research that note the importance of the school environment in adolescent behavior (Eccles & Barber, 1999). Furthermore, not addressed in the literature, is the potential relationship between physical activity and school variables related to academic guidelines and standards for athletes. Often, schools will enforce grade point average limits for athletes involved in school sponsored sports. These requirements may be a potential explanation for this positive relationship between academic performance and physical activity. Finally, television use was a significant negative predictor of physical activity in all groups except tenth graders in 1999. Higher television hours predicted lower reported physical activity level.

The Ecological Model explained a small amount of the variance in physical activity in each year studied. Only 10-11% of the variance in physical activity was explained by the proposed model. While these results are low, they are consistent with other studies (Ammouri et al., 2007; Garcia et al., 1995).

The examination of the different years allows for inferences about physical activity over time. Neighborhood safety, parental support, high-school

program, competition for grades, and school attachment were significant predictors of physical activity in all years in both eighth and tenth grades. Furthermore, the standardized regression weights of these variables remained relatively constant over time. No statistically significant differences were observed between regression weights across years in tenth grade, but significant differences in regression weights across years were found in eighth grade. Additionally, the significant predictors did not seem to change over time. Furthermore, there were no significant changes in reported physical activity over time. Although the trend was for a slight decline over time, these results were nonsignificant. Thus, the Ecological Model remains a good framework for the evaluation of physical activity despite the changes in political climate, recommendations for activity, or state policies related to schools.

Physical Activity and Substance Use

These three studies examined the predictors of physical activity, tobacco use, and alcohol use from an ecologic perspective. Potential relationships between health and risk behavior were investigated. Few studies have examined these potential relationships and mutual influence of health and risk behaviors from an ecologic perspective.

Individual and school factors were the strongest predictors of adolescent risk behavior regardless of substance. Attitude, perception of risk, and academic performance were the strongest predictors of both tobacco use and physical activity. These findings support past studies as to the importance of the

adolescent's individual ideas and beliefs related to the substance as well as the importance of the school environment.

Conversely, family context variables did not have as strong of influence on risk behavior as in previous studies. However, parental support did emerge as a strong predictor of physical activity. This relationship was present in 1992, 1999, and 2004 in both eighth and tenth grade groups. Thus, parental support has remained an important factor related to physical activity over time. Furthermore, parental support in this study was general in nature and was not specific to physical activity. While previous studies have identified physical activity family support as influential to determining adolescent physical activity behavior, this study identifies the fact that any type of support may have a positive influence on physical activity behavior in adolescents.

Physical activity as a predictor of risk behavior yielded interesting results. In the tobacco use study physical activity had a significant direct negative influence on tobacco use in tenth grade females. In the alcohol study, however, physical activity had a direct positive influence on alcohol use in both tenth grade males and females. Interestingly, other significant predictors from the Ecological Model were consistent between substances. Variables from the individual context and school context were the most significant predictors for both tobacco use and alcohol use. In each study the strongest predictors of substance use were attitude toward substance, perceived risk of substance, work hours, and academic performance.

These conflicting findings in physical activity influence indicate that although physical activity may play a significant role influencing risk behaviors, not all risk behaviors are equal. One possible explanation for the difference is the potential effect of tobacco use on lung function during aerobic exercise. If adolescents experience impaired pulmonary function during physical activity they may be less likely or able to participate. Additionally, there may be a social aspect of substance use not evaluated in this study. Certain teams or athletic groups may be more likely to participate in drinking behavior together, thus increasing the report of both physical activity and alcohol use. More research is needed to determine the potential influence of physical activity on substance use.

Physical activity level did not change the effect of ecological variables that predicted substance use. Only school attachment and television use were influenced by physical activity in these studies. Furthermore, no consistencies were observed between substances or grades. Physical activity lessened the effects of school attachment on tobacco use in eighth grade. Adolescents who had low attachment to school were less likely to use tobacco products when they were highly physically active. Additionally, physical activity lessened the effect of television use on alcohol use in tenth grade. Higher television hours were less likely to predict alcohol use, but only when the adolescent also reported higher levels of physical activity. Thus, there is some protective role of physical activity on substance use, however, it did not have an effect on all variables in the Ecological Model.

When physical activity was examined further, differences were observed between the amounts of physical activity participation. In the tobacco study significant differences were observed between levels of participation in physical activity. Those adolescents who reported more physical activity also reported less tobacco use indicating that physical activity itself may have a general protective role for those adolescents at risk of using tobacco. The opposite was true for the alcohol use study, however. No significant differences were observed between high and low physical activity groups. Those adolescents who were highly physically active were just as likely to report alcohol use as those who reported lower levels of physical activity.

While physical activity does not change the effect of many of the Ecological variables, it may play a role in influencing adolescent risk behavior. The significant differences in tobacco use between physical activity level point to a need for further research to examine the exact nature of this relationship. The fact that no significant differences in physical activity groups were observed in the alcohol use study implies that physical activity affects substance use in different ways. This notion is further supported by the opposite significant direct effects observed on the substance when physical activity was entered into the regression equation as an independent variable. Higher amounts of physical activity were predictive of both lower tobacco use and higher reported alcohol use. Other factors not measured in this study may have also had an influence on this relationship. Peer pressure and influence, the physiologic effects of the substance and physical activity on the body, and adolescent beliefs may play a

role in this discrepancy and should be further evaluated with prospective and longitudinal studies.

Finally, perceived environmental predictors of physical activity did not significantly change over time. No significant differences were observed in predictors of physical activity in 1992, 1999, and 2004. The strongest predictors over all years were school connectedness or attachment and general parent support. Explained variance in physical activity was consistent across years as well. The model explained 10-11% of the variance in physical activity and was not statistically different from year to year. Furthermore, significant differences in reported physical activity were observed each year between males and females. Males consistently reported more physical activity than their female counterparts. These results indicate that despite interventions and political initiatives aimed at increasing physical activity not much change has been observed in reported physical activity in adolescent groups. In fact, the amount of physical activity reported and the significant predictors of physical activity have remained stable over time.

Limitations

These studies had several limitations. Most importantly, these studies are a secondary data analysis. Data analyzed were collected as part of a much larger on going study examining adolescent's attitudes and experience with a variety of different substances. While the theoretical framework for the MTF study is not explicit, it was not originally intended to be used with the Ecological Model or to study physical activity as it relates to substance use. Thus, all factors from the

Ecological Model were not included in the original research. Selected variables and concepts from each context were looked at as a preliminary evaluation of the potential use of the Ecological Model to examine these issues.

Secondly, the MTF study was not intended to examine physical activity as an outcome. Only two questions asked specifically about physical activity. Furthermore, these two questions were combined to form one physical activity variable. There may be differences between those adolescents who reported levels of physical activity based on individual behaviors and those who reported levels of physical activity based on participation in organized sports teams. These studies did not allow those potential differences to be examined. In addition, physical activity is usually measured by frequency, intensity, and duration. In this study, only physical activity frequency was measured thereby potentially limiting the results. Thus, it is difficult to determine an adolescent's compliance with the current recommended guidelines. Although he or she may state that he or she participates in physical activity nearly every day, the duration and intensity of physical activity is missing. Future studies should quantify the amount of physical activity to determine adherence to recommendations. Furthermore, since the purpose of the MTF study was not physical activity, the measures for the independent variables did not have the same target outcome, context, or time. Thus, the measures may not accurately reflect physical activity participation in this group.

Finally, data are cross sectional in nature and causality cannot be assumed. As with most survey data, results rely on self-report. While measures were taken

to maximize honest responses, the intimate subject matter of the original instrument may influence or bias the responses. Addition of objective measures, such as serum levels of nicotine and ethanol and use of an accelerometer to measure physical activity, would strengthen findings and implications although would likely not be feasible in such a large sample size. Finally, the sample size is very large and yields many significant results. Conservative measures were taken to account for this large sample size and counter this limitation. Results were only considered significant at p levels less than .001 and data were weighted for all analyses.

Implications for Future Research

Overall, the Ecological Model of Adolescent Behavior had good fit to the data and explained a small to moderate amount of variance in physical activity and substance use. Individual and school factors emerged as the strongest predictors of all behaviors studied. While the exact relationship of physical activity to risk factors cannot be determined, differences were observed in substance use based on physical activity level. Furthermore, physical activity had significant direct effects on substance use. Thus, further research investigating the role and relationship of physical activity with other risk and protective factors is needed.

Adolescent physical activity and substance use are complex behaviors with many significant predictors and associations. This study supports others that recommend multi-level interventional studies aimed at these behaviors to improve adolescent health (Chaloupka & Johnston, 2007; Ferreira et al., 2007). Studies

aimed at the individual, school, and social levels could influence the adolescent from a variety of sources and have a greater impact on behavior (Ashe et al., 2007; Reininger et al., 2005). Research that considers these contexts and influences of the targeted behavior has the potential to have more successful outcomes (McKay, Bell-Ellison, Wallace, & Ferron, 2007).

These findings suggest a potential link between adolescent health and risk behavior. Furthermore, these studies identify the individual and school contexts as the strongest ecologic predictors, although weak, of tobacco and alcohol use and family support and the school context as the strongest environmental predictors of physical activity. Finally, these results support previous research in that there are significant gender differences in health and risk behavior. The exact relationship of physical activity to tobacco and alcohol use is unclear from the current studies although interesting findings were present. These preliminary results support additional studies to identify the exact nature of the relationship between physical activity, substance use, gender, and ecologic factors.

More exploration is needed utilizing the Ecological Model to explore relationships between risk and protective factors and adolescent behavior. Moreover, studies are needed to determine which types of changes in noted significant predictors will produce the greatest impact on physical activity and substance use (Gordon-Larsen, Nelson, Page, & Popkin, 2006). Future studies should be prospective or longitudinal in design and include an objective measure of physical activity to support and validate findings as well as investigate additional predictors of physical activity and substance use.

Implications for Nursing Practice

Nurses are in a unique position in healthcare to work with patients across the lifespan in a variety of settings. This study points out the importance of addressing both individual and school factors to influence tobacco use, alcohol use, and physical activity. Nurses who work with adolescents are able to assess the adolescent's attitude toward substances and perceived risk of the substance. Once baseline knowledge and attitudes are established, nurses can educate adolescents in an effort to decrease tobacco and alcohol use. Furthermore, nurses can work within the schools to provide education, support, and interventions aimed at increasing physical activity. Nurses can also work to change policy at schools to increase physical activity by working with state legislatures, coaches and trainers, and with school sports teams. Finally, nurses can work independently or as part of a multidisciplinary team to continue to research the potential relationship between risk and protective factors in this important age group.

Summary

Individual and school variables play a significant role in both tobacco use and alcohol use. Attitude toward substance, perceived risk of substance, work hours, and school performance all influence adolescent substance use behavior. Neighborhood safety, high school program, competition for grades, and school attachment influence physical activity participation. Family support, although not specific for exercise or activity, has a positive effect on reported levels of physical

activity. Furthermore, significant predictors of physical activity have been stable over time.

Adolescence is a time of exploration and influence. Behaviors that are initiated in adolescence have the potential to carry over into adulthood.

Adolescent rates of tobacco use and alcohol use are alarmingly high while rates of physical activity are low. An ecological or environmental approach to adolescent behavior research provides insight into potential solutions for these problems. The Ecological Model of Adolescent Behavior can guide practice and research aimed at increasing physical activity and decreasing substance use. Specifically, research and interventions aimed at the individual and school contexts has the potential to greatly impact adolescent behavior.

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