The Pennsylvania State University

The Graduate School

College of Health and Human Development

PUBERTAL TIMING, TYPE OF MOTIVATION, AND PERCEIVED ATHLETIC COMPETENCE AS PREDICTORS OF ADOLESCENT GIRLS' PHYSICAL ACTIVITY

A Dissertation in

Leisure Studies

by

Birgitta L. Baker

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

August 2008

The dissertation of Birgitta L. Baker was reviewed and approved* by the following:

Alan R. Graefe
Associate Professor of Recreation, Parks, and Tourism Management
Dissertation Adviser
Co-Chair of Committee

Kirsten K. Davison
Assistant Professor of Health Policy, Management and Behavior
University at Albany, SUNY
Co-Chair of Committee

Andrew J. Mowen
Associate Professor of Recreation, Parks, and Tourism Management

Deborah L. Kerstetter
Associate Professor of Recreation, Parks, and Tourism Management

Leann L. Birch
Distinguished Professor of Human Development and Family Studies

John P. Dattilo
Department Head, Professor of Recreation, Parks, and Tourism Management

*Signatures are on file in the Graduate School.

ABSTRACT

This study examined biological, social, psychological factors that predict adolescent girls' physical activity. Specifically, pubertal timing, body fatness, type of motivation, and perceived athletic competence were examined. Three article manuscripts comprise the body of the dissertation.

The relationship between pubertal timing and subsequent physical activity was examined in the first manuscript (Chapter 2). Girls with more advanced pubertal status at age 11 were less physically active at age 13.

Type of motivation was the focus of the second paper (Chapter 3). Self-determination theory was used to guide the analyses in this chapter. Results from logistic regression analyses indicated that age 9 perceived athletic competence and parental autonomy granting were positively related to girls' intrinsic motivation for physical activity across ages 9-13 and negatively related to girls' extrinsic (weight related) motivation for physical activity across ages 9-13. Intrinsic motivation was, in turn, positively related to girls' accelerometer-measured physical activity at age 13.

The role of perceived athletic competence in predicting physical activity was examined in the third manuscript (Chapter 4). Results indicated that both age 11 perceived athletic competence and the change in perceived athletic competence between ages 11 and 13 were significant predictors of age 13 physical activity. Age 11 perceived athletic competence was predicted by age 9 sport participation and body fat percentage while the change in perceived athletic competence between ages 11 and 13 was predicted by age 9 breast development. Taken together, these studies highlight the complexity of factors related to adolescent girls' physical activity. Findings from these three papers suggest that puberty and perceived athletic competence are related to adolescent girls' physical activity. In addition, the importance of examining both point estimates and changes across time is illustrated by the results from these studies.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Physical activity is associated with a variety of positive mental and physical health benefits for children and adolescents. Because of this, the Centers for Disease Control and Prevention (CDCP, 2006) recommends that adolescents engage in at least 60 minutes of moderate-to-vigorous physical activity (MVPA) on most days of the week. There is, however, a preponderance of evidence that the majority of adolescents do not meet these recommendations and that the deficit is particularly striking among adolescent girls. In 2003-2004, less than 12% of male adolescents and less than 5% of female adolescents engaged in at least 60 minutes of MVPA on most days of the week (Troiano et al., 2008) This is consistent with repeated findings that girls are less active than boys throughout adolescence (Jago, Anderson, Baranowski, & Watson, 2005; Van Mechelen, Twisk, Post, Snel, & Kemper, 2000; Vilhjalmsson & Kristjansdottir, 2003). Furthermore, while rates of MVPA decline in both males and females during adolescence (CDCP, 2006), the mean rate of decline is higher for females than for males (Aaron, Storti, Robertson, Kriska, & LaPorte, 2002; Caspersen, Pereira, & Curran, 2000; CDCP, 2006; Kimm et al., 2002; National Center for Health Statistics, 2005). While the overall trend of decline is well documented, not all individuals evidence this decrease in physical activity across adolescence (Anderssen, Wold, & Torsheim, 2005). Therefore, it is important to identify the reasons for both the general low levels of physical activity and the divergence in individual patterns among adolescent girls.

In addition to age, a variety of psychological, behavioral, social, and environmental correlates of adolescent girls' physical activity have been identified in the literature. Unfortunately, much of the research to date has been cross-sectional in nature and/or used self-reported measures of physical activity (Biddle, Gorely, & Stensel, 2004). Psychological variables positively associated with adolescent girls' physical activity include perceived competence (Biddle & Wang, 2003; Raudsepp & Liblik, 2002), self-efficacy (Dishman et al., 2004; R. W. Motl et al., 2005), and enjoyment (Dishman et al., 2005; Neumark-Sztainer, Story, Hannan, Tharp, & Rex, 2003). Participation in organized competitive sport is the primary behavioral variable associated with adolescent girls' physical activity (Biddle, Whitehead, O'Donovan, & Nevill, 2005). In addition, researchers have found moderate support for a relationship of parent, sibling, and peer modeling and support with physical activity (Biddle et al., 2004). Relationships between environmental factors such neighborhood design and access to recreational facilities and adolescent girls' physical activity have also been identified (Kligerman, Sallis, Ryan, Frank, & Nader, 2004; Norman et al., 2006). In addition, policy changes such as Title IX legislation have been associated with significant increase in girls' physical activity (Stevenson, 2007). While there is a body of research focused on correlates of adolescent girls' physical activity, the paucity of longitudinal data and objectively measured physical activity is a significant limitation (Biddle et al., 2005). In addition, many of the identified relationships are based on a small number of studies and further research is necessary to strengthen these claims.

The Life Course Perspective (LCP) and Social Cognitive Theory (SCT) provide frameworks for examining changes and individual differences in physical activity. The Life Course Perspective focuses on the ways in which development occurs over time and highlights key concepts such as transitions and context that can help to elucidate differences in developmental processes that lead to individual variance in behaviors such as physical activity (Elder & Shanahan, 2006). While LCP highlights the importance of environmental context, social interaction, and individual life events in shaping trajectories of behavior, it provides little insight into the mechanisms linking these factors. Social Cognitive Theory (SCT) may cast light on these mechanisms as it provides a theoretical framework illustrating potential means by which environmental context and social relations interact with cognitive processes to produce behavior. Taken together, LCP and SCT highlight the importance of transitions such as puberty and psychological variables such as motivation for physical activity and perceived athletic competence that may provide insight into the reasons for the low levels of physical activity displayed by most adolescent girls and the patterns displayed by girls who engage in higher levels of physical activity.

This dissertation comprises three papers that focus on factors that may be related to adolescent girls' physical activity. Life Course Perspective and Social Cognitive Theory provide the unifying theoretical basis for these three papers as they guide the focus on transitions and psychological processes that may be related to the observed variations in adolescent girls' physical activity. Paper One addresses the relationship between pubertal timing at age 11 and girls' physical activity at age 13. In Paper Two, Self-Determination Theory is tested using predictors and physical activity outcomes of intrinsic and extrinsic activity motivation across ages 9-13. The focus of Paper Three is predictors and outcomes of perceived athletic competence at age 11 and the change in perceived athletic competence between ages 11 and 13.

Physical Activity and Health

Physical activity is associated with a variety of positive physical and mental health outcomes for children and adolescents although causal links have not been established (Biddle, Gorely, & Stensel, 2004; Strong et al., 2005). The discrepancy between recommended and actual levels of adolescent girls' physical activity makes it likely that the majority of girls do not reap the potential health benefits. Adolescent physical activity levels also exhibit moderate levels of tracking into adulthood, further benefiting those who are active during adolescence (Hallal, Victora, Azevedo, & Wells, 2006). Existing research on adolescents has suggested beneficial links between exercise and a variety of measures of physical health including lipid levels (Kang et al., 2002), blood pressure (Strong et al., 2005), adiposity (Eliakim et al., 2002), and bone density (French, Fulkerson, & Story, 2000; MacKelvie, Khan, McKay, & Sanborn, 2002). The effects of most of these variables (lipid levels, blood pressure, and bone density) become evident later in life when cardiovascular disease and osteoporosis develop (Biddle et al., 2004; Hallal et al., 2006). Adolescent adiposity, however, impairs health and quality of life during both adolescence and adulthood (Dietz, 1998; Rocchini, 2002). In addition to physical health benefits, a variety of mental and social benefits are associated with physical activity. These include lower levels of depression (Motl, Birnbaum, Kubik, & Dishman, 2004; Norris, Carroll, & Cochrane, 1992) and anxiety (Norris, Carroll, & Cochrane, 1992) and higher levels of social functioning (Allison et al., 2005) and self-concept (Annesi, 2005).

Adolescent Girls' Physical Activity

In response to the range of positive outcomes associated with higher levels of physical activity, a number of agencies have issued physical activity recommendations for children and adolescents. Previous recommendations advised moderate activity for 30 minutes or more on at least 5 days of the week or vigorous activity for 20 minutes or more on at least three days per week (CDCP, 2006). Current recommendations for older children and adolescents advise at least 60 minutes of moderate-to-vigorous physical activity most days of the week (CDCP, 2006; US Department of Agriculture & US Department of Health and Human Services, 2000). According to the CDCP, physical activity is "bodily movement that is produced by the contraction of skeletal muscle and that substantially increases energy expenditure" (US Department of Health and Human Services, 1996). The Centers for Disease Control and Prevention (CDCP) and the American College of Sports Medicine (ACSM) delineate intensity levels of physical activity based on the proportional increase in energy expenditure or oxygen consumption associated with an activity above that expended at rest. Resting metabolic rate is one metabolic equivalent (MET; 3.5 ml O2 • kg-1 • min-1) (US Department of Health and Human Services, 1996). The CDC and ACSM use the following cutoffs for physical activity intensity levels: <3 METS = light; 3-6 METS = moderate; >6 METS = vigorous (Pate et al., 1995). Three METS is approximately equivalent to brisk walking (US Department of Health and Human Services, 1996).

Despite the benefits of physical activity, the majority of adolescents do not meet the current recommendations. In 2003-2004, less than 12% of male adolescents and less than 5% of female adolescents met current physical activity recommendations of least 60 minutes of moderate-to-vigorous physical activity on at least five days in the previous week (Troiano et al., 2008). In a sample of eighth grade girls, Jago et al. (2005) calculated an average of less than 15 minutes of accelerometer measured moderate-to-vigorous physical activity per day. Taken together, these studies suggest that the majority of adolescents do not achieve the level of physical activity required to obtain health benefits.

While males display consistently higher levels of physical activity than females throughout adolescence (CDCP, 2006), researchers have found that both genders evidence a significant decline in moderate to vigorous physical activity over time and that this decline is steeper for girls than for boys (Aaron, Storti, Robertson, Kriska, & LaPorte, 2002; Caspersen, Pereira, & Curran, 2000; CDCP, 2006; Kimm et al., 2002; National Center for Health Statistics, 2005). Using data from the National Health Interview Survey-Youth Risk Behavior Survey, Casperson et al. (2000) found that the percentage of female adolescent respondents engaging in regular sustained activity (at least 30 minutes per day of walking or biking on 5 days of the week) dropped from 30% to 20% between age 12 and 17 while the percentage engaging in regular vigorous activity (running, swimming or jogging on 3 or more days of the week) dropped from 66% to 28% between ages 12 and 20. These gender related discrepancies in physical activity levels and rate of decline indicate that adolescent girls may be at increased risk for the negative health outcomes discussed above.

Adolescent Development and Girls' Physical Activity

Characteristics of the experience of adolescence may provide insight into the reasons for the documented low levels of adolescent girls' physical activity. Although adolescence is thought of as a troubled and turbulent time, research has indicated that for the majority of adolescents it is far less difficult than often imagined (Shapka & Keating, 2005). Adolescence is, nonetheless, a time of significant physical, emotional, and social changes (Singleton, 2007). These changes mark a period of transition from childhood to adulthood as the individual becomes capable of reproduction (Patton & Viner, 2007) and is generally considered to encompass the years from age 10 to the early twenties. This time period is further divided into early (10-13 yrs), middle (14-17 yrs), and late (18 – early 20s yrs) adolescence (Smetana, Campione-Barr, & Metzger, 2006). These demarcations are not, however, clear-cut; biological and social changes are more relevant markers of this life stage than are chronological years. Adolescence is generally identified as beginning with the striking biological, psychological, and social changes associated with puberty and ending with the significant role-shifts associated with entering adulthood (Graber & Brooks-Gunn, 1996; Patton & Viner, 2007). The transition into adolescence is more clearly demarcated than the exit as there is considerable variation in the timing of adult-defining transitions such as marriage, completion of education, and entering the labor force (Smetana, Campione-Barr, & Metzger, 2006).

Significant biological, psychological, and social changes characterize the transitions into and out of adolescence and the intervening years. Many of the biological changes females experience during adolescence are associated with puberty. These include rapid growth, increased adiposity, and the development of secondary sexual characteristics such as breasts (Paikoff & Brooks-Gunn, 1991; Pinyerd & Zipf, 2005). Adolescent girls undergo a variety of psychological changes, some of which are associated with the physical changes they experience. Rates of depression among adolescent girls diverge from those of adolescent boys with the rate for girls outpacing that of boys (Patton & Viner, 2007). Self-esteem also decreases and body image concerns increase during early adolescence before stabilizing in later adolescence (Steinberg & Morris, 2001). Not all psychological changes that occur during adolescence are negative. Adolescents increase in autonomy (Soenens et al., 2007), cognitive functioning (Patton & Viner, 2007), and sense of self (Susan Harter, 2006) as they transition from childhood to adulthood. Not surprisingly, alterations in social relationships accompany these psychological changes.

Relationships with both parents and peers change during adolescence as evolution in both autonomy and interdependence allow the emergence of more adult relationships. The development of a sense of independence, particularly from parents, is a defining feature of adolescence (Collins & Steinberg, 2006). This does not mean, however, that relationships are unimportant during this time. Increasing autonomy is associated with a change in, rather than a severing of, the bond between parents and their adolescent children. This change results in a more equitable relationship as the child reaches adulthood (Paikoff & Brooks-Gunn, 1991;

Steinberg & Morris, 2001). At the same time as parent-child relationships are altering to assume a more balanced state, peer relationships are increasing in importance and closeness (Collins & Steinberg, 2006). As they age, the proportion of their time adolescents spend with family members decreases concomitantly with an increase in the proportion of time they spend with their peers (Collins & Steinberg, 2006; Paikoff & Brooks-Gunn, 1991; Smetana, Campione-Barr, & Metzger, 2006).

The developmental changes associated with adolescence are associated with changes in leisure during this period. US adolescents spend an average of 6-8 hours per day in discretionary or ‘free time’ activities (Larson & Seepersad, 2003; Zick, 2007), making leisure an important developmental context. Leisure is unique among adolescent contexts in its affordance of self-directed behavior (Darling, Caldwell, & Smith, 2005) and its opportunities for identity exploration (Sharp, Caldwell, Graham, & Ridenour, 2006). Within this relatively autonomous context, there is considerable variation in the ways in which youth choose to spend their time and much of it is taken up with activities that are unlikely to promote positive development (Sharp et al., 2006). For example, US youth spend an average of 1.5-2.5 hours per day watching television (Larson & Seepersad, 2003). A variety of gender differences in leisure time use have been identified, some of which encompass differences in leisure time physical activity. Boys are more likely than girls to participate in sports (Darling et al., 2005; Larson & Seepersad, 2003) and this is a significant contributor to the overall difference in physical activity between boys and girls (Aaron et al., 2002, James, 2001). On the other hand, girls are more likely than boys to participate organized extracurricular activities other than sports (Larson & Seepersad, 2003) and also spend more time alone than boys (James, 2001). In addition, the constraints to leisure differ by gender. Girls report more constraints that do boys (Raymore, Godbey, & Crawford, 1994) and are particularly likely to report constraints such as low body esteem (James, 2000) and lack of skills (Raymore, Godbey, & Crawford, 1994).

Differences in girls' and boys' experiences of puberty may account for some of the gender differences in leisure behaviors. Social gender expectations that encourage male sport participation to a greater degree than female sport participation may become more salient as the physical changes of puberty provide constant reminders to a pubescent girl and her social circle of her femininity. In addition, gender differences in reports of poor body esteem and a lack of skills as constraints to activity participation may reflect the reality of differences in the outcomes of the physical changes associated with puberty. While these changes tend to increase boys' athletic prowess and reduce the discrepancy between boys' actual shape and the societal ideal, the reverse is true for girls.

In summary, adolescence is a developmental period that spans a considerable length of time and significant physical, psychological, and social transformations. Many of these changes may trigger the declines in physical activity observed during adolescence. Therefore, to truly reveal the processes responsible for the observed declines, it is necessary to gather longitudinal data and to identify patterns of stability and change in attitudes and behaviors. The Life Course Perspective (LCP) (Elder & Shanahan, 2006) provides a paradigm for examining the ways in which development occurs over time and identifies key concepts and principles that can help to elucidate differences in developmental processes that lead to individual variance in behaviors such as physical activity. In addition, Social Cognitive Theory describes mechanisms by which the processes described by the Life Course Perspective interact to produce behaviors.

Using Theory to Inform Research on Declines in Adolescent Girls' Physical Activity

The Life Course Perspective. LCP highlights the interaction between person and context in shaping individual outcomes (Elder & Shanahan, 2006; Hutchison, 2005). The "cumulative effects of an entire sequence of developmental transitions over an extended period of the person's life" (Bronfenbrenner, 1986) are studied as a collection of processes (Elder & Shanahan, 2006). In other words, LCP emphasizes the importance of viewing individual development as a group of interconnected cumulative trajectories that are shaped by societal forces and individual transitions. LCP provides a framework within which to examine physical activity as a specific trajectory that a girl generates within the constraints of her environment. It also draws our attention to the importance of social pathways in determining the opportunities that adolescent girls have for physical activity, the importance of individual agency in determining the course of a girl's physical activity trajectory, the role of transitions as potential turning points in physically active or sedentary behavior, the relevance of the timing of transitions, and the significant impact that the cumulative effect of many small choices may have on levels of physical activity.

Social and institutional pathways are age-graded, socially-normed successions of roles and events that provide a context and a set of constraints within which individuals make the choices that create their life courses (Elder, Johnson, & Crosnoe, 2003; Elder & Shanahan, 2006). Because these pathways are age-graded and socially normed, they provide a standard for identifying early, on-time, and late individuals (Elder & Shanahan, 2006). Social pathways, including school, community, and government structures may limit or enhance the opportunities that girls have to be physically active. As girls progress through adolescence, opportunities to engage in organized physical activity may decline. For example, mandatory physical education requirements decline with increases in school grade (Bungum & Vincent, 1997). In addition, changing demands of school and work responsibilities may reduce discretionary time and the individual may not prioritize physical activity (Rehman et al., 2003).

Within the constraints imposed by social and institutional pathways, girls will develop individual pathways also known as cumulative patterns and trajectories (Elder & Shanahan, 2006). The effects of choices are cumulative and over time small decisions create long term patterns that make up individual life-course trajectories (Elder & Shanahan, 2006; Hutchison, 2005). In the case of physical activity, patterns established in childhood and adolescence track moderately into adulthood (Hallal, Victora, Azevedo, & Wells, 2006). Trajectories are often characterized by behavioral continuities that may be maintained by either their consequences (cumulative) that add up over time to strengthen the pattern of behavior or by responses from the environment (reciprocal) that result in a reinforcing cycle (Elder & Shanahan, 2006). For example, girls who engage in lower levels of physical activity will miss out on opportunities to develop skills and fitness. A lack of skills and fitness will then strengthen their sedentary pattern of behavior.

Within trajectories, transitions may simply be markers along a relatively continuous trajectory or they may provide an opportunity for an abrupt change of direction (Elder & Shanahan, 2006). Transitions generally involve a change in role (Elder & Shanahan, 2006) and may be normative (e.g. puberty, child bearing, labor force entry) or non-normative (e.g. acquiring a disability, death of a child) (Bronfenbrenner, 1986). The impact of a transition on future outcomes is often dependent on the timing of the transition (Elder & Shanahan, 2006). For example, early pubertal timing has been associated with negative outcomes among adolescent girls when compared with relatively on-time pubertal maturation (Elder & Shanahan, 2006;

Lanza & Collins, 2002; McCabe & Ricciardelli, 2004; Simon, Wardle, Jarvis, Steggles, & Cartwright, 2003; Tremblay & Frigon, 2005).

A transition that provides an opportunity for an abrupt change of direction is characterized as a turning point (Elder & Shanahan, 2006). Turning points are defined as “a special life event that produces a lasting shift, not simply a detour, in the life course trajectory” (Hutchinson, 2003, p. 145). This shift may be constructive, leading to increased choices and positive outcomes, or destructive, leading to truncated choices and negative outcomes (Elder & Shanahan, 2006). The transition between middle school and high school (Elder & Shanahan, 2006) or the experience of puberty may be a turning point in an adolescent’s physical activity trajectory. The transition from one school to another may result in a previously active girl becoming far less active if she is not able to participate in sports with more stringent selection criteria than she experienced at her middle school (Bungum & Vincent, 1997). The experience of puberty, particularly if it occurs early compared with her peers, may lead to a girl avoiding physical activity as a result of discomfort with the changes she is experiencing. Early pubertal maturation in females is a risk factor for a variety of negative outcomes and risk behaviors including obesity (Tremblay & Frigon, 2005), smoking (Simon, Wardle, Jarvis, Steggles, & Cartwright, 2003), alcohol and drug use (Lanza & Collins, 2002), body dissatisfaction (McCabe & Ricciardelli, 2004), and adjustment problems (Simon, Wardle, Jarvis, Steggles, & Cartwright, 2003). It has been hypothesized that each of these problems arise due to the deviation from societal body ideals and the increase in popularity with the opposite sex that may be caused by pubertal changes in body shape among girls (McCabe & Ricciardelli, 2004).

In addition to the influence of social and institutional pathways, LCP highlights the role of important others in shaping trajectories. Networks of shared relationships act as informal control agents in influencing a person's trajectory (Elder & Shanahan, 2006). Activity levels of adolescent girls may be influenced by a variety of important others including parents, teachers, siblings, and peers through behaviors such as peer-pressure, modeling, and instrumental support (Beets, Pitetti, & Forlaw, 2007; Davison, Cutting, & Birch, 2003; Dwyer et al., 2006).

Despite the restrictions and influences of institutional forces and social relationships, individuals are not viewed as being at the mercy of circumstances. Within the constraints imposed by and the opportunities offered through the environment, the individual creates the trajectories that make up his/her life course (Bronfenbrenner & Morris, 2006; Elder & Shanahan, 2006). In the case of physical activity, a girl will not be able to engage in a sport that is not offered in her geographic area (an environmental constraint) however, she may or may not participate in an activity that is offered in her school.

Social Cognitive Theory. While LCP highlights the importance of environmental context, social interaction, and individual life events in shaping trajectories of behavior, it provides little insight into the mechanisms linking these factors. Social Cognitive Theory (SCT) provides a theoretical framework illustrating potential means by which environmental context and social relations interact with cognitive processes to produce behavior. This theory is a "transactional view of self and society" in which it is posited that "internal personal factors in the form of cognitive, affective and biological events; behavior; and environmental events all operate as interacting determinants that influence one another bidirectionally" (Bandura, 1997, p. 6). This triadic interchange is labeled reciprocal determinism (Bandura, 2001). In other words, behavior is determined by an individual's assessment of the likely outcomes of his/her behavior and his/her appraisal of the desirability of those outcomes within the constraints of the environment

(Bandura, 1997, 2001). SCT involves explanations of both the development of competencies (learning) and the regulation of action (Bandura 2001).

There is considerable overlap between in constructs between LCP and SCT. Within SCT, social structures refer to formal and informal systems that “organize, guide, and regulate human affairs in given domains by authorized rules and sanctions” (Bandura, 1997, p. 6). This concept is analogous to the social and institutional pathways in the Life Course Perspective. Also similar to LCP is the tenet of SCT that humans are not, however, pawns of their environment. They are posited to both shape and be shaped by social and environmental conditions (Bandura, 1997, 2001). In addition, LCP and SCT share a focus on the role of others in shaping individual’s behavior.

While LCP and SCT share many basic premises, SCT elaborates on mechanisms that shape behavior to a degree that LCP does not. Two key constructs highlighted by SCT are motivation and self-efficacy. Within the area of motivation, intentionality and forethought highlight the cognitive aspect of SCT. Behaviors are generally posited to be the result of actions that follow from intentions. While individuals do engage in some involuntary behavior, the majority of behavior is seen to be the result of a plan of action based on cognitive models of anticipated consequences and outcomes. These effects may be based on enjoyment or personal satisfaction. Alternatively, the anticipation of external consequences such as social sanctions/approval, physical pain, or monetary rewards may guide intentions (Bandura, 2001). According to theories of motivation such as Self-determination Theory (SDT), enjoyment and personal satisfaction are classified as intrinsic motivation while external consequences are deemed extrinsic motivation (Ryan & Deci, 2000). When compared with individuals who are more extrinsically motivated, intrinsically motivated individuals show higher levels of persistence in a sport setting (Pelletier, Fortier, Vallerand, & Briere, 2001), intention to exercise (Hagger, Chatzisarantis, & Harris, 2006), and participation in physical activity (Ntoumanis, 2005).

Closely linked to the ability of anticipated outcomes to motivate behavior is self-efficacy. Perceived self-efficacy is defined as “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p. 3). Without the belief that one has the ability to achieve the desired level of performance, an individual will not be motivated to attempt the behavior. Efficacy beliefs impact human behavior both directly and indirectly. According to Bandura (2001), “among the mechanisms of personal agency, none is more central or pervasive than people’s beliefs in their capability to exercise some measure of control over their own functioning and over environmental events” (p. 10). Self-efficacy affects whether or not an individual will initiate an action and the effort and persistence he/she will apply (Bandura & Adams, 1977). Self-efficacy is domain specific which means that an individual may have high self-efficacy in one area and low self-efficacy in another (Bandura, 1997). Sources of self-efficacy include enactive attainment (having completed a task in the past one is likely to believe that it is repeatable); vicarious experience (watching a similar other perform a task or using others performance as a standard for social comparison); verbal persuasion (having a credible other express his/her belief in one’s ability to accomplish the task); and physiological and affective states (interpreting the causes and potential consequences of physiological states as benign or positive, rather than negative or threatening). All of these sources require the creation of cognitive models of success (Bandura, 1997).

According to Bandura’s Social Cognitive Theory, declines in a behavior (in this case physical activity) may result from a change in the outcome expectancies associated with a behavior, in the value placed on the expectancies, or in the individual's self-efficacy related to the behavior. These factors may change during adolescence in ways that result in declines in physical activity. As peers become more salient during adolescence and a focus on relationships with members of the opposite sex develops (Grotevant, 1998), Girls who previously valued outcomes associated with physical activity such as being described as strong or fast may begin to prefer feedback that they are beautiful or feminine and choose to engage in pursuits that are likely to elicit those responses. Alternatively, girls' physical activity self-efficacy may decline during adolescence as a result of physical and social changes associated with pubertal development. New constraints of time (Neumark-Sztainer, Story, Hannan, Tharp, & Rex, 2003), heightened self-consciousness (James, 2000), and decreased performance (Malina & Bouchard, 1991) may further erode a girl's belief that she can successfully engage in physical activity.

A variety of areas of study are suggested when the LCP and SCT are used to examine patterns of adolescent girls' physical activity. Research on transitions such as puberty and cognitive processes such as motivations for physical activity (Edmunds, Ntoumanis, & Duda, 2006) and perceived athletic competence (Bandura, 1997) may provide insight into the reasons for the documented low levels of adolescent girls' physical activity and the variations among adolescent girls' levels of physical activity. These factors have not, however, been examined in longitudinal data spanning preadolescence to early adolescence (i.e. ages 9-13 years). These years are of particular interest as they are likely to encompass many of the dramatic changes associated with puberty. Elucidating these relationships would enable interventions to be targeted in ways that are most likely to lead to increased physical activity. Therefore, the purpose of this dissertation is to examine the relationships between biological (puberty), psychological (perceived competence and motivation), and social (parent-child relationships) factors and subsequent physical activity. Based on the literature in this area, the following research questions were developed:

RQ1: Is adolescent girls' pubertal development related to subsequent physical activity?

RQ2: Is type of motivation predictive of physical activity in adolescent girls and, if so, what predicts type of motivation?

RQ3: Does adolescent girls' perceived athletic competence predict subsequent physical activity? If so:

a) What are some predictors of perceived athletic competence?

b) Does perceived athletic competence exert influence through intervening variables?

The Current Studies

Based on previous research examining puberty, motivation, perceived competence, and patterns of adolescent girls' physical activity, three studies were conducted to examine factors that might help to explain the variation in adolescent girls' physical activity using data from the Girls' NEEDs and TeenACT research projects.

The Girls' NEEDs project is a longitudinal study focused on the emergence of dieting in girls. A variety of self report and clinical measures have been collected from parents and daughters. Data were collected when the girls were 5, 7, 9, 11, and 13 years old. They are currently 15 or 16 years old. At age 13, TeenACT was initiated with the goal of adding measures related to physical activity, including accelerometer.

Participants. Participants in this study were girls recruited in central Pennsylvania using flyers, newspaper advertisements, and targeted mailings and phone calls. Two cohorts of girls were recruited for the study. Girls in cohort 1 were born in 1990 and 1991. Girls in cohort 2 were born in 1991 and 1992. Data collection began in 1996 for cohort 1 and 1997 for cohort 2.

Data Collection. Data for the studies in this dissertation were collected during the summer and fall of the years the girls were age 9, 11, and 13. Groups of 3-5 girls visited Penn State University (PSU) for a day of data collection during the summer months. A trained research assistant accompanied each girl throughout the day. During this time, clinical measures and questionnaire data were obtained. Clinical measures were obtained by a registered nurse or a trained research assistant at the PSU General Clinical Research Center. Questionnaire data were obtained either through an interview administered process in which the research assistant asked the girl questions from an instrument or through a self administered process in which the girl filled in her responses to an instrument. The choice of administration method depended on the content and complexity of the questionnaire. Questionnaire data were also collected from mothers and fathers either at PSU or via mail.

Accelerometer data were collected during the fall of the year the girl turned 13. Trained research assistants either visited the girl's home or met with her at her school to explain the protocol, demonstrate correct use of the accelerometer, and obtain responses to additional questionnaires related to physical activity.

Paper one. Paper One addresses RQ1 with a focus on the relationship between pubertal timing and subsequent physical activity. As described above, puberty is a key adolescent transition and therefore, according to the LCP, provides an opportunity for significant changes in individual trajectories. The experience of the biological, psychological, and social changes associated with puberty may lead to declines in physical activity. The effects of puberty are not, however, equal for all girls. Timing of puberty is particularly important as girls who experience puberty early relative to their peers are at greater risk for a variety of negative outcomes. The purpose of this study is to examine whether timing of puberty is related to subsequent levels of physical activity through testing the following hypothesis:

H1: Girls with more advanced pubertal status at age 11 will have lower levels of physical activity at age 13 when controlling for age 11 weight status.

Paper two. Paper Two addresses RQ 2 and RQ3b with a focus on motivation for physical activity. SCT highlights the importance of motivation in determining behavior. Motivation is central to the initiation and maintenance of activity (Ryan & Deci, 2000) and therefore, changes in motivation across time may be related to the observed declines in physical activity among adolescent girls. Intrinsic motivation (fun, enjoyment, satisfaction) is predictive of higher levels of adherence to an activity than are extrinsic motivations such as guilt, social pressure, or threat of punishment or reward (Hagger, Chatzisarantis, & Harris, 2006; Ntoumanis, 2005; Pelletier, Fortier, Vallerand, & Briere, 2001). Therefore, it would be reasonable to expect that girls with high sustained levels of intrinsic motivation are more physically activity than girls who are extrinsically motivated or lack motivation. One type of extrinsic motivation for physical activity that may be particularly salient for adolescent girls is weight related motivation. Puberty related changes such as an increase in adiposity combined with increasing pressure to conform to social preferences regarding physical appearance may be associated with the documented increases in weight concerns during this time period (Carlson Jones, 2004; Monsma, Malina, & Feltz, 2006). According to Self Determination Theory (SDT) relatedness (a sense of connection to others), perceived competence (a belief in one's ability to accomplish a task), and autonomy (a sense of independence and freedom from external compulsion) are antecedents of intrinsic motivation (Ryan & Deci, 2000). The purpose of this paper is to examine predictors of levels of intrinsic and extrinsic motivation across ages 9-13 and the relationship type of motivation and physical activity using a SDT framework. The following hypotheses are tested:

H1: Level of extrinsic motivation for physical activity across ages 9 to 13 is predicted by perceived athletic competence (negative), parental encouragement of autonomy (negative), and quality of relationship with parents (negative) at age 9.

H2: Level of intrinsic motivation for physical activity across ages 9 to 13 is predicted by perceived athletic competence (positive), parental encouragement of autonomy (positive), and quality of relationship with parents (positive) at age 9.

H3: Girls with consistently high levels of intrinsic motivation have higher levels of physical activity at age 13 than do other girls.

H4: Girls with consistently high levels of extrinsic motivation do not have higher levels of physical activity at age 13 than do other girls.

Paper three. Paper 3 addresses RQ3. Perceived athletic competence is positively associated with participation in physical activity (Sollerhed, Apitzsch, Rastam, & Ejlertsson, 2008; Trost et al., 1997; Welk & Schaben, 2004), which may be a result of the links between perceived competence, intrinsic motivation, and persistence in the face of challenges (S. Harter, 1985). The association between perceived athletic competence and physical activity has not, however, been extensively studied in adolescent girls. Furthermore, little is known about the predictors of girls' perceived competence. The studies that have been conducted have generally relied on cross-sectional data and/or self-reported physical activity, which limits their application. A detailed examination of predictors and outcomes of perceived athletic competence in adolescent girls may help to inform intervention efforts with this vulnerable population. Therefore, the purpose of this paper is to examine precursors of girls' perceived athletic competence and change in perceived competence and links between perceived competence and girls' objectively measured physical activity. The following hypotheses are tested in this paper:

H1: Age 9 participation in aesthetic sports (positive), participation in non-aesthetic sports (positive), body fatness (negative), and breast development (negative) will be predictors of age 11 level and age 11-13 change in perceived athletic competence in the direction indicated beside them.

H2: Age 11 level of perceived competence and change in perceived athletic competence between ages 11 and 13 will be positive predictors of age 13 MVPA.

References

Aaron, D. J., Storti, K. L., Robertson, R. J., Kriska, A. M., & LaPorte, R. E. (2002). Longitudinal study of the number and choice of leisure time physical activities from mid to late adolescence: implications for school curricula and community recreation programs. *Archives of Pediatric and Adolescent Medicine, 156*(11), 1075-1080.

Allison, K. R., Adlaf, E. M., Irving, H. M., Hatch, J. L., Smith, T. F., Dwyer, J. M., et al. (2005). Relationship of vigorous physical activity to psychologic distress among adolescents. *Journal of Adolescent Health, 37*(2), 164.

Anderssen, N., Wold, B., & Torsheim, T. (2005). Tracking of physical activity in adolescence. *Research Quarterly for Exercise and Sport, 76*(2), 119.

Annesi, J. J. (2005). Improvements in self-concept associated with reductions in negative mood in preadolescents enrolled in an after-school physical activity program. *Psychological reports, 97*(2), 400-404.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52*, 1-26.

Bandura, A., & Adams, N. (1977). Analysis of self-efficacy theory of behavioral change. *Cognitive Therapy and Research, 1*(4), 287-310.

Beets, M. W., Pitetti, K. H., & Forlaw, L. (2007). The role of self-efficacy and referent specific social support in promoting rural adolescent girls' physical activity. *American Journal of Health Behaviors, 31*(3), 227-237.

Biddle, S. J., Gorely, T., & Stensel, D. (2004). Health-enhancing physical activity and sedentary behaviour in children and adolescents. *Journal of Sports Sciences, 22*, 679-701.

Biddle, S. J., & Wang, C. K. (2003). Motivation and self-perception profiles and links with physical activity in adolescent girls. *Journal of Adolescence, 26*(6), 687-701.

Biddle, S. J., Whitehead, S. H., O'Donovan, T. M., & Nevill, M. E. (2005). Correlates of participation in physical activity for adolescent girls: A systematic review of recent literature. *Journal of Physical Activity and Health, 2*, 423-434.

Bronfenbrenner, U. (1986). Ecology of the family as a context for human development: research perspectives. *Developmental Psychology, 22*(6), 723-742.

Bronfenbrenner, U., & Morris, P. (2006). The Bioecological Model of Human Development. In R. Lerner (Ed.), *Handbook of Child Psychology* (Vol. One: Theoretical Models of Human Development, pp. 793-828). Hoboken: John Wiley & Sons, Inc.

Bungum, T. J., & Vincent, M. L. (1997). Determinants of physical activity among female adolescents. *American Journal of Preventive Medicine, 13*(2), 115-122.

Carlson Jones, D. (2004). Body image among adolescent girls and boys: A longitudinal study. *Developmental Psychology, 40*(5), 823-835.

Caspersen, C. J., Pereira, M. A., & Curran, K. M. (2000). Changes in physical activity patterns in the United States, by sex and cross-sectional age. *Medicine and Science in Sports and Exercise, 32*(9), 1601-1609.

CDCP. (2006). Youth risk behavior surveillance--United States, 2005. *Morbidity and mortality weekly report. CDC surveillance summaries, 55*(5), 1-108.

Collins, W. A., & Steinberg, L. (2006). Adolescent development in interpersonal context. In N. Eisenberg, W. Damon & R. Lerner (Eds.), *Handbook of Child Psychology: Social, Emotional, and Personality Development* (6th ed., Vol. 3, pp. 1003-1068). Hoboken, NJ: John Wiley & Sons Inc.

Darling, N., Caldwell, L. L., & Smith, R. (2005). Participation in school-based extracurricular activities and adolescent adjustment. *Journal of Leisure Research, 37*(1), 51-77.

Davison, K. K., Cutting, T. M., & Birch, L. L. (2003). Parents' activity-related parenting practices predict girls' physical activity. *Medicine and Science in Sports and Exercise, 35*(9), 1589-1595.

Dietz, W. H. (1998). Health consequences of obesity in youth: Childhood predictors of adult disease. *Pediatrics, 101*(3 Supplement), 518-525.

Dishman, R. K., Motl, R. W., Saunders, R., Felton, G., Ward, D. S., Dowda, M., et al. (2004). Self-efficacy partially mediates the effect of a school-based physical-activity intervention among adolescent girls. *Preventive Medicine, 38*(5), 628-636.

Dishman, R. K., Motl, R. W., Saunders, R., Felton, G., Ward, D. S., Dowda, M., et al. (2005). Enjoyment mediates effects of a school-based physical-activity intervention. *Medicine and Science in Sports and Exercise, 37*(3), 478–487.

Dwyer, J. J., Allison, K. R., Goldenberg, E. R., Fein, A. J., Yoshida, K. K., & Boutilier, M. A. (2006). Adolescent girls' perceived barriers to participation in physical activity. *Adolescence, 41*(161), 75-89.

Edmunds, J., Ntoumanis, N., & Duda, J. L. (2006). A test of self-determination theory in the exercise domain. *Journal of Applied Social Psychology, 36*(9), 2240-2265.

Elder, G., Johnson, M. K., & Crosnoe, R. (2003). The emergence and development of life course theory. In J. Mortimer & M. Shanahan (Eds.), *Handbook of the Life Course* (pp. 3-19). New York: Kluwer Academic/Plenum Publishers.

Elder, G., & Shanahan, M. (2006). The life course and human development. In R. M. Lerner (Ed.), *Handbook of Child Psychology* (Sixth ed., Vol. One: Theoretical Models of Human Development, pp. 665-715). Hoboken, New Jersey: John Wiley & Sons, Inc.

Eliakim, A., Kaven, G., Berger, I., Friedland, O., Wolach, B., & Nemet, D. (2002). The effect of a combined intervention on body mass index and fitness in obese children and adolescents-a clinical experience. *European Journal of Pediatrics, 161*(8), 449-454.

French, S. A., Fulkerson, J. A., & Story, M. (2000). Increasing weight-bearing physical activity and calcium intake for bone mass growth in children and adolescents: A review of intervention trials. *Preventive Medicine, 31*(6), 722-731.

Graber, J. A., & Brooks-Gunn, J. (1996). Transitions and turning points: Navigating the passage from childhood through adolescence. *Developmental Psychology*, *32*(4), 768-776.

Grotevant, H. (1998). Adolescent development in family contexts. In N. Eisenberg (Ed.), *Handbook of Child Psychology* (Fifth ed., Vol. Three: Social, Emotional, and Personality Development): Jeffrey W. Brown.

Hagger, M. S., Chatzisarantis, N. L. D., & Harris, J. (2006). The process by which relative autonomous motivation affects intentional behavior: Comparing effects across dieting and exercise behaviors. *Motivation and Emotion, 30*(4), 307-321.

Hallal, P. C., Victora, C. G., Azevedo, M. R., & Wells, J. C. K. (2006). Adolescent physical activity and health: A systematic review. *Sports Medicine, 36*, 1019-1030.

Harter, S. (1985). *Manual for the self-perception profile for children*. Denver, CO: University of Denver

Harter, S. (2006). The Self. In W. Damon & R. M. Lerner (Eds.), *Handbook of Child Psychology: Social, Emotional, and Personality Development* (Vol. 3, pp. 505-570). Hoboken, NJ: Wiley & Sons Inc.

Hutchison, E. (2005). The life course perspective: A promising approach for bridging the micro and macro worlds for social workers. *Families in Society, 86*(1), 143-152.

Jago, R., Anderson, C. B., Baranowski, T., & Watson, K. (2005). Adolescent patterns of physical activity differences by gender, day, and time of day. *American Journal of Preventive Medicine, 28*(5), 447-452.

James, K. (2000). "You can feel them looking at you": The experiences of adolescent girls at swimming pools. *Journal of Leisure Research, 32*(2), 262-280.

James, K. (2001). 'I just gotta have my own space!': The bedroom as a leisure site for adolescent girls. *Journal of Leisure Research, 33*(1), 71–90.

Kang, H. S., Gutin, B., Barbeau, P., Owens, S., Lemmon, C. R., Allison, J., et al. (2002). Physical training improves insulin resistance syndrome markers in obese adolescents. *Medicine and Science in Sports and Exercise, 34*(12), 1920-1927.

Kimm, S. Y., Glynn, N. W., Kriska, A. M., Barton, B. A., Kronsberg, S. S., Daniels, S. R., et al. (2002). Decline in physical activity in black girls and white girls during adolescence. *The New England Journal of Medicine, 347*(10), 709-715.

Kligerman, M., Sallis, J. F., Ryan, S., Frank, L. D., & Nader, P. R. (2004). Association of neighborhood design and recreation environment variables with physical activity and body mass index in adolescents. *American Journal of Health Promotion, 21*(4), 274-277.

Lanza, S. T., & Collins, L. M. (2002). Pubertal timing and the onset of substance use in females during early adolescence. *Prevention Science, 3*(1), 69-82.

Larson, R., & Seepersad, S. (2003). Adolescents' leisure time in the United States: Partying, sports, and the American experiment. *New Directions in Child and Adolescent Development, 99*, 53-64.

MacKelvie, K. J., Khan, K. M., McKay, H. A., & Sanborn, C. (2002). Commentary. *British Journal of Sports Medicine, 36*(4), 250-257.

Malina, R. M., & Bouchard, C. (1991). *Growth, maturation, and physical activity*. Champaign, IL: Human Kinetics.

McCabe, M. P., & Ricciardelli, L. A. (2004). A longitudinal study of pubertal timing and extreme body change behaviors among adolescent boys and girls. *Adolescence, 39*(153), 145-166.

McCabe, M. P., & Ricciardelli, L. A. (2004). A longitudinal study of pubertal timing and extreme body change behaviors among adolescent boys and girls. *Adolescence, 39*(135), 145-166.

Monsma, V. E., Malina, M. R., & Feltz, L. D. (2006). Puberty and physical self-perceptions of competitive female figure skaters: An interdisciplinary approach. *Research Quarterly for Exercise and Sport, 77*(2), 158.

Motl, R. W., Birnbaum, A. S., Kubik, M. Y., & Dishman, R. K. (2004). Naturally occurring changes in physical activity are inversely related to depressive symptoms during early adolescence. *Psychosomatic Medicine, 66*(3), 336-342.

Motl, R. W., Dishman, R. K., Ward, D. S., Saunders, R. P., Dowda, M., Felton, G., et al. (2005). Perceived physical environment and physical activity across one year among adolescent girls: Self-efficacy as a possible mediator? *Journal of Adolescent Health, 37*(5), 403-408.

National Center for Health Statistics. (2005). *Health, United States, 2005 With Chartbook on Trends in the Health of Americans.* . Hyattsville, Maryland: National Center for Health Statistics.

Neumark-Sztainer, D., Story, M., Hannan, P., Tharp, T., & Rex, J. (2003). Factors associated with changes in physical activity. *archives of Pediatric and Adolescent Medicine, 157*, 803-810.

Norman, G. J., Nutter, S. K., Ryan, S., Sallis, J. F., Calfas, K. J., & Patrick, K. (2006). Community design and access to recreational facilities as correlates of adolescent physical activity and body-mass index. *Journal of Physical Activity and Health, 3*(S1), S118-S128.

Norris, R., Carroll, D., & Cochrane, R. (1992). The effects of physical activity and exercise training on psychological stress and well-being in an adolescent population. *Journal of Psychosomatic Research, 36*(1), 55-65.

Ntoumanis, N. (2005). A prospective study of participation in optional school physical education using a self-determination theory framework. *Journal of Educational Psychology, 97*(3), 444-453.

Paikoff, R. L., & Brooks-Gunn, J. (1991). Do parent-child relationships change during puberty? . *Psychological Bulletin, 110*(1), 47-66.

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., et al. (1995). Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *Journal of the American Medical Association, 273*(5), 402-407.

Patton, G. C., & Viner, R. (2007). Pubertal transitions in health. *The Lancet, 369*(9567), 1130-1139.

Pelletier, L. G., Fortier, M. S., Vallerand, R. J., & Briere, N. M. (2001). Associations among perceived autonomy support, forms of self-regulation, and persistence: A prospective study. *Motivation and Emotion, 25*(4), 279-306.

Pinyerd, B., & Zipf, W. B. (2005). Puberty-timing is everything! *Journal of Pediatric Nursing, 20*(2), 75-82.

Raudsepp, L., & Liblik, R. (2002). Relationship of perceived and actual motor competence in children. *Percept Mot Skills, 94*(3 Pt 2), 1059-1070.

Raymore, L. A., Godbey, G. C., & Crawford, D. W. (1994). Self-esteem, gender, and socioeconomic status: Their relation to perceptions of constraint on leisure among adolescents. *Journal of Leisure Research, 26*(2), 99-118.

Rehman, L., Campagna, P., Kirby, I., Ness, G. W., Murphy, R. J. L., Rasmussen, R., et al. (2003). I just want to have fun, but can I?: Examining leisure constraints and negotiation by children and adolescents. *World Leisure Journal, 45*(2), 22–31.

Rocchini, A. P. (2002). Childhood obesity and a diabetes epidemic. *The New England Journal of Medicine, 346*(11), 854-855.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78.

Shapka, D. J., & Keating, P. D. (2005). Structure and change in self-concept during adolescence. *Canadian Journal of Behavioural Science, 37*(2), 83.

Sharp, E. H., Caldwell, L. L., Graham, J. W., & Ridenour, T. A. (2006). Individual motivation and parental influence on adolescents' experiences of interest in free time: A longitudinal examination. *Journal of Youth and Adolescence, 35*(3), 340.

Simon, A. E., Wardle, J., Jarvis, M. J., Steggles, N., & Cartwright, M. (2003). Examining the relationship between pubertal stage, adolescent health behaviours and stress. *Psychological Medicine, 33*(8), 1369-1379.

Singleton, L. L. (2007). Developmental differences and their clinical impact in adolescents. *British Journal of Nursing, 16*(3), 140-143.

Smetana, J. G., Campione-Barr, N., & Metzger, A. (2006). Adolescent development in interpersonal and societal contexts. *Annual Review of Psychology, 57*(1), 255-284.

Soenens, B., Vansteenkiste, M., Lens, W., Luyckx, K., Goossens, L., Beyers, W., et al. (2007). Conceptualizing parental autonomy support: Adolescent perceptions of promotion of independence versus promotion of volitional functioning. *Developmental Psychology, 43*(3), 633-646.

Sollerhed, A. C., Apitzsch, E., Rastam, L., & Ejlertsson, G. (2008). Factors associated with young children's self-perceived physical competence and self-reported physical activity. *Health Education Research. (23)*1, 125-136.

Steinberg, L., & Morris, A. S. (2001). Adolescent development. *Annual Review of Psychology, 52*(1), 83-110.

Stevenson, B. (2007). Title IX and the evolution of high school sports. *Contemporary Economic Policy, 25*(4), 486-505.

Strong, W. B., Malina, R. M., Blimkie, C. J. R., Daniels, S. R., Dishman, R. K., Gutin, B., et al. (2005). Evidence based physical activity for school-age youth. *The Journal of Pediatrics, 146*(6), 732-737.

Tremblay, L. L., & Frigon, J. Y. (2005). The interaction role of obesity and pubertal timing on the psychosocial adjustment of adolescent girls: Longitudinal data. *International Journal of Obesity, 29*(10), 1204-1211.

Troiano, R. P., Berrigan, D., Dodd, K. W., Masse, L. C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine & Science in Sports & Exercise, 40*(1), 181-188.

Trost, S., Pate, R., Saunders, R., Ward, D. S., Dowda, M., & Felton, G. (1997). A prospective study of the determinants of physical activity in rural fifth-grade children. *Preventive Medicine, 26*, 257-263.

US Department of Agriculture, & US Department of Health and Human Services. (2000). *Nutrition and your health: Dietary guidelines for Americans.* Washington, DC: US Government Printing Office.

US Department of Health and Human Services. (1996). *Physical Activity and Health. A Report of the Surgeon General*. Atlanta, GA: US Department of Health and Human Services; Centers for Disease Control and Prevention.

Van Mechelen, W., Twisk, J. W., Post, G. B., Snel, J., & Kemper, H. C. (2000). Physical activity of young people: The Amsterdam Longitudinal Growth and Health Study. *Medicine and Science in Sports and Exercise, 32*(9), 1610-1616.

Vilhjalmsson, R., & Kristjansdottir, G. (2003). Gender differences in physical activity in older children and adolescents: The central role of organized sport. *Social Science in Medicine, 56*(2), 363-374.

Welk, G. J., & Schaben, J. A. (2004). Psychosocial Correlates of Physical Activity in Children-A Study of Relationships When Children Have Similar Opportunities to Be Active. *Measurement in Physical Education and Exercise Science, 8*(2), 63-81.

Zick, C. D. (2007). *Over-scheduled or at loose ends? The shifting balance of adolescent time use*. Paper presented at the Annual Meeting of the Population Association of America. New York City, March 29-31

Orientation to Chapter 2

This chapter is a manuscript that was published in the Journal of Pediatrics. The purpose of this paper was to explore the relationship between pubertal timing and subsequent physical activity. The following hypothesis was tested:

H1. Girls with more advanced pubertal status at age 11 will have lower levels of physical activity at age 13 when controlling for age 11 weight status.

This paper has been published with the following citation:

Baker, B. L., Trost, S. G., Birch, L. L., & Davison, K. K. (2007). Advanced pubertal status at age 11 and lower physical activity in adolescent girls. *Journal of Pediatrics, 151*(5), 488-493

CHAPTER 2

ADVANCED PUBERTAL STATUS AT AGE 11 AND LOWER PHYSICAL ACTIVITY IN ADOLESCENT GIRLS

Abstract

OBJECTIVE: Few studies have assessed why girls experience declines in physical activity during adolescence. This study examines the relationship between pubertal timing and physical activity. STUDY DESIGN: A longitudinal sample of 143 adolescent girls was assessed at ages 11 and 13 years. Girls' pubertal development was assessed at age 11 using blood estradiol levels, Tanner breast staging criteria, and parental report of pubertal development. Girls were classified as early maturers (N=41) or later maturers (N=102) based on their scores on the three pubertal development measures. Dependent variables measured at age 13 were average minutes/day of moderate to vigorous (MVPA) and vigorous (VPA) physical activity as measured by the ActiGraph accelerometer. RESULTS: Early maturing girls had significantly lower self-reported physical activity and accumulated fewer minutes of MVPA, VPA, and accelerometer counts per day at age 13 than later maturing girls. These effects were independent of differences in percentage body fat and self-reported physical activity at age 11. CONCLUSION: Girls experiencing early pubertal maturation at age 11 reported lower subsequent physical activity at age 13 than their later maturing peers. Pubertal maturation, in particular early maturation relative to peers, may lead to declines in physical activity among adolescent girls.

.

Introduction

Although the health benefits of physical activity are widely promoted, many youth do not meet physical activity recommendations. In 2005, only 59.9 percent of adolescent girls in the U.S. participated in at least 30 minutes of moderate physical activity or 20 minutes of vigorous activity on three or more days per week (National Center for Health Statistics, 2005). Furthermore, both males and females evidence a decline in physical activity across adolescence. Adolescent girls report lower levels of physical activity than boys from middle childhood onward (Jago, Anderson, Baranowski, & Watson, 2005; Trost et al., 2002) and exhibit greater rates of decline in physical activity across adolescence (National Center for Health Statistics, 2005).

Few studies have examined factors that predict or explain the noted decline in physical activity among adolescent girls. One particular factor leading to low physical activity among girls may be the psychological experience of puberty, and in particular the timing of pubertal maturation. Early pubertal maturation in females is a risk factor for a variety of negative outcomes and risk behaviors including obesity (Tremblay & Frigon, 2005), smoking (Simon, Wardle, Jarvis, Steggles, & Cartwright, 2003), alcohol and drug use (Lanza & Collins, 2002), body dissatisfaction (McCabe & Ricciardelli, 2004), and adjustment problems (Simon, Wardle, Jarvis, Steggles, & Cartwright, 2003). It has been hypothesized that each of these problems arise due to the deviation from societal body ideals and the increase in popularity with the opposite sex that may be caused by pubertal changes in body shape among girls (McCabe & Ricciardelli, 2004).

While links between pubertal maturation and physical activity have been examined in a number of studies, the vast majority of studies to date have examined physical activity as a predictor, rather than a consequence, of pubertal maturation. In general, these studies found that competitive female athletes reported later menarche than non-athletes (Malina, Bouchard, & Bar-Or, 2004; Torstveit & Sundgot-Borgen, 2005). Later menarche among athletes was hypothesized to be the result of differences in percentage body fat and energy balance (Loucks, 2003; Roemmich, Richmond, & Rogol, 2001) . More recent studies indicate that much of the difference in pubertal timing between athletes and non-athletes is the result of self, coach or parent selection of girls into sports (Malina, Bouchard, & Bar-Or, 2004; Rogol, Clark, & Roemmich, 2000) in response to their physical stature, suggesting that pubertal maturation may be the initiating factor in the link between pubertal timing and physical activity. To the authors' knowledge, pubertal timing has not been examined as a precursor to low physical activity among adolescent girls. Therefore, using a longitudinal sample of girls examined at ages 11 and 13 years, this study tests the hypothesis that girls who experience early pubertal maturation at age 11 will exhibit lower subsequent levels of physical activity at age 13 compared to later maturing girls. Although the authors acknowledge that the rate of change in maturation, or tempo, is also important to consider, rate of change will not be addressed in this study due to insufficient data to test this hypothesis.

Methods

Participants

Participants were 143 adolescent non-Hispanic white girls who were part of a longitudinal study examining girls' nutrition, dieting, physical activity, and health. Approval for research involving human participants was obtained from the Institutional Review Board at the Pennsylvania State University. Participants were assessed at ages 11 (mean=11.33, std=.29) and 13 (mean=13.32, std=.28) years. Parents and the participants provided written informed consent for all procedures. Only girls (N= 143), who had measures of both pubertal development and physical activity, were included in the current study. No differences in girls' Body Mass Index (BMI), girls' self reported physical activity, girls' breast development, fathers' education or family income, were noted for girls who were and were not included in the final sample.

Measures

Girls' BMI, percent body fat, and self-reported physical activity were measured at ages 11 and 13 years. Data regarding pubertal status, parental education and family income were collected at age 11. An objective assessment of girls' physical activity (using accelerometers) was obtained at age 13.

Measures of body composition

Body Mass Index (BMI) and overweight status. Girls' height and weight were measured in triplicate and were used to calculate their BMI (weight (kg)/height $(m)^2$). Age and sex-specific BMI percentiles and z-scores were calculated using the 2000 growth charts from the Centers for Disease Control and Prevention. Girls with a BMI percentile > 85 and < 95 were defined as "at risk of overweight" and girls with a BMI percentile of > 95 were defined as overweight (Kuczmarski, Kuczmarski, & Roche, 2002).

Percent Body Fat. Dual-energy X-Ray absorptiometry (DXA) was used to measure girls' percent body fat. Whole body scans were done using the Hologic QDR 4500W (S/N 47261) in the array scan mode and analyzed using whole body software, QDR4500 Whole Body Analysis. DXA has received widespread use and is the preferred method of assessing body composition among children, because it provides an accurate, reliable, and non-invasive means of quantifying bone mineral content and body mass content, including fat and lean mass, while minimizing radiation exposure during measurement (Ellis, Shypailo, Pratt, & Pond, 1994; Goran, Driscoll, Johnson, Nagy, & Hunter, 1996; Lukaski, 1993; Mazess, Barden, Bisek, & Hanson, 1990).

Measures of pubertal development

Estradiol. Blood samples collected on filter paper were used to measure levels of estradiol (pg/mL). Girls arrived at the laboratory at 7:45 am after an overnight fast. All blood samples were collected between 8 am and 9 am. The samples were air dried and then frozen until assayed as outlined by Shirtcliff and colleagues (2000). The estradiol assay has been validated against serum samples in both adults and children and its sensitivity is sufficient for the detection of pre-pubertal levels of estradiol in girls. Specifically, the minimum concentration at which estradiol could be distinguished from 0 was 2 pg/mL. The intra assay coefficient of variation was 16% and the inter assay coefficient was 8.9%.

Breast Development. Girls' breast development was assessed using Tanner's criteria for pubertal breast stages (Marshall & Tanner, 1969). Stages range from 1 (no development) to 5 (mature development). Visual inspection of each breast was made unobtrusively by a trained nurse and a nurse's assistant while using a stethoscope to check heart rate. In cases where ratings of the two breasts were not equal, the lower stage was used because the girl had not fully attained the higher stage.

Pubertal development scale (PDS). Mothers provided information on their daughter's pubertal development by completing the PDS (Peterson, Tobin-Richards, & Boxer, 1983). The PDS is a non-intrusive measure of pubertal development and consists of six items assessing growth or change in height, the presence of body hair (including underarm and pubic hair), skin changes especially the presence of pimples, breast development, and menstruation. Previous research supports the reliability and validity of this scale (Peterson, Crockett, Richards, & Boxer, 1988; Peterson, Tobin-Richards, & Boxer, 1983).

Classification of timing of puberty

Each measure of pubertal development outlined above has strengths and weaknesses. Estradiol assay provides an objective measure of a hormone associated with pubertal development. There is, however, substantial between individual variation in level of estrogen at any stage of pubertal development and within individual variation throughout the menstrual cycle, making it difficult to determine a specific cut-off to define early maturation. The assessment of breast development can also be problematic. Although we were able to obtain a visual assessment of breast development, rather than relying on self-reports from girls, fat tissue can be mistaken for breast tissue in cases where the breast is not palpated. A key advantage of this method, however, is that it is widely used by researchers and clinicians thereby increasing its applicability. Finally, the advantage of the PDS is that it is simple and inexpensive to administer. It is, however, based on the assumption that mothers are knowledgeable about daughters' pubertal status.

Because of the strengths and weaknesses described above, information from these three measures were combined into an overall index of pubertal status, which categorized girls as having either earlier or later timing of puberty at age 11 relative to the sample. Earlier developers were girls who fulfilled two of the following three criteria: (a) highest tertile for estradiol; (b) Tanner stage 3 or higher for breast development; and (c) highest tertile for the PDS. Using these criteria, 41 girls were classified as earlier developers and 102 were classified as later developers (see Table 2.1 for details regarding group characteristics). The aforementioned criteria were chosen in order to identify a select group of girls who were clearly more physically mature than girls of the same age. Consequently, these groups indicate timing of puberty relative to same age peers in the sample and are not intended as clinical indices of either precocious or delayed puberty.

Measures of physical activity

Self-reported physical activity. The Children's Physical Activity scale (CPA) was used to measure girls' self-reported physical activity at ages 11. In a self-administered survey, girls responded to 15 questions such as "I participate in sports almost every day" using a 4-point scale ranging from 1=completely false to 4=completely true. Scores on the fifteen items were averaged to create a score ranging from one (low activity) to four (high activity). In previous studies, scores on the CPA have been correlated in the expected direction with one-mile run/walk time ($r = -.43$, $p < 0001$), body fat percentage ($r = -.41$, $p <.0001$), and BMI ($r = - .32$, $p <.0001$) (Tucker, Seljaas, & Hager, 1997). The internal consistency co-efficient for the CPA in this study was α=.73 indicating acceptable internal reliability.

Objectively-measured physical activity. Objective assessments of physical activity were obtained using the ActiGraph 7164 accelerometer (Shalimar, FL). The ActiGraph is a uniaxial accelerometer designed to detect vertical accelerations ranging in magnitude from 0.05 to 2.00 G's with a frequency response of 0.25 – 2.50 Hz. These parameters allow for the detection of normal human motion and will reject high frequency vibrations encountered during activities such as operation of a lawn mower. The filtered acceleration signal is digitized, rectified, and integrated over a user-specified epoch interval. At the end of each epoch, the summed value or "activity count" is stored in memory and the integrator is reset. For the current study, a 30 s epoch was used. The Actigraph 7164 has been shown to be a valid and reliable tool for assessing physical activity in children and adolescents (Trost et al., 1998).

After receiving detailed instructions regarding the care and use of the accelerometers, girls were instructed to wear the ActiGraph at all times, except when bathing and swimming, for 7 consecutive days. Consistent with previous studies, the ActiGraph was worn on the right hip (mid-axilla line at the level of the iliac crest). Non-wearing time for each monitoring day was calculated by counting the number of zero counts accumulated in strings of 20 minutes or longer. Girls were included in the analyses if they had 4 or more days with 10 or more hours of wearing time (Masse et al., 2005). Previous work has shown that 4 days of monitoring provides reliable estimates of usual physical activity in adolescent youth (Trost, McIver, & Pate, 2005). In this study, 75.2% of girls had 7 valid monitoring days, with 14.3%, 6.8%, and 3.8% providing 6, 5, and 4 valid days, respectively. Among the participants with 4 or more valid monitoring days, daily wear time ranged from 763.4 minutes to 1282 minutes, with an average of 1086 ± 116 minutes.

Raw accelerometer counts were uploaded to a customized software program for determination of total daily counts, and daily time spent in moderate (MPA), vigorous (VPA), and moderate-to-vigorous (MVPA) physical activity. The age-specific count thresholds corresponding to the aforementioned intensity levels were derived from the MET prediction equation developed by Freedson and co-workers (Freedson, Pober, & Janz, 2005; Trost et al., 2002). To accommodate the 30-sec epoch length, count thresholds were divided by 2 (Nilsson, Ekelund, Yngve, & Sjostrom, 2002).

Statistical analyses

Differences in body composition and physical activity between earlier maturing and later maturing girls at ages 11 and 13 were assessed using t-tests. The relationship between pubertal timing and subsequent physical activity was assessed using multiple regression analysis.

Specifically, pubertal timing at age 11 was used to predict subsequent physical activity at age 13, controlling for physical activity and percentage body fat at age 11. A composite measure of family SES status created using principal components analysis of mother's education, father's education, and family income was also entered as a covariate in analyses. Outcome variables at age 13 included minutes of MVPA and VPA, and raw accelerometer counts; a separate regression model was run for each outcome variable. Self-reported physical activity at age 11 was entered as a covariate to account for the likely scenario that girls who are more physically active at age 11 are also more physically active at age 13 (Rogol, Clark, & Roemmich, 2000). Percent body fat at age 11 was entered as a covariate to account for the possibility that girls with higher body fat percentages had both earlier pubertal timing and lower levels of physical activity and that body fatness, rather than pubertal timing was responsible for differences in physical activity at age 13. Pubertal status was entered as a dichotomous variable.

Results

Sample characteristics

The percentage of girls who lived in households with reported incomes of less than $35, 000, $35,001 to $49, 999, or $50,000 or more per year was 16%, 24% and 60% respectively. The average years of education for mothers was 14.42 years and for fathers was 14.89 years. Based on the composite pubertal development variable, 30% (n = 41) of the girls were classified as earlier maturers and 70% (n= 102) of the girls were classified as later maturers. With respect to weight status, at age 11, 31% of girls were at risk of overweight and 13% were overweight. At age 13, 28% of the girls were at risk of overweight and 12% were overweight.

At age 11, earlier maturing girls had significantly higher height, weight, percent body fat, and BMI scores than later maturing girls (see Table 2.2). No significant group differences in self-reported physical activity were noted at age 11. At age 13, earlier maturing girls continued to have significantly higher weight and BMI scores and had significantly higher percent body fat than later maturing girls. There was no height difference between early and late maturing girls. Significant differences were noted in both accelerometer and self-report measures of physical activity at age 13 with early maturing girls being less physically active.

Links between pubertal timing at age 11 and subsequent physical activity at age 13

As shown in Table 2.3, pubertal timing at age 11 was a significant predictor of objectively measured physical activity at age 13. After controlling for age 11 physical activity (CPA), percent body fat, and SES earlier maturating girls engaged in significantly fewer minutes per day of MVPA and VPA at age 13 than later developers. In comparison to later maturing girls, earlier maturing girls engaged on average in 6.6 fewer minutes per day, or 46 fewer minutes per week, of MVPA and 2.17 per day, or 15 minutes per week, of VPA. Similarly, early pubertal maturation at age 11 was associated with significantly lower total accelerometer counts per day at age 13 after controlling for covariates. Adding age and height as covariates did not affect the results of the analysis.

Discussion

Results from this study indicate that earlier timing of pubertal development at age 11 is associated with lower levels of physical activity at age 13. This relationship remained after controlling for body fatness, self-reported physical activity and family SES at age 11. Consequently, the identified associations are not driven by pre-established levels of physical activity (i.e., low active girls maturing more quickly than high active girls) or body fat (i.e., girls who are more overweight and more sedentary going through puberty earlier than their leaner peers). These findings indicate that early maturing girls are at an increased risk of physical inactivity during adolescence and that additional research on possible factors explaining this association is warranted.

Early pubertal timing combined with low levels of physical activity may place girls at particular risk of negative health outcomes Previous research indicates that early pubertal maturation is linked with negative mental and physical health outcomes such as poor body image (Michaud, Suris, & Deppen, 2006), eating pathology (McCabe & Ricciardelli, 2004) , and increased breast cancer risk (Ma, Bernstein, Pike, & Ursin, 2006; Shantakumar et al., 2006; Velie, Nechuta, & Osuch, 2005). Physical inactivity is also a risk factor for negative health outcomes such as obesity (Trost, Kerr, Ward, & Pate, 2001), cardiovascular disease (Caspersen, Pereira, & Curran, 2000; Spear, 2002), diabetes (Hale, 2004), depression (Motl, Birnbaum, Kubik, & Dishman, 2004), ovarian cancer (Pan, Ugnat, & Mao, 2005), and lower levels of social functioning (Allison et al., 2005). Drawing together these two bodies of research suggests that early maturing girls who are inactive may experience compounded risk for negative health outcomes. The possibility of increased risk among early maturing girls provides further justification for research on mechanisms linking early maturation and physical inactivity and ways to promote physical activity in this high risk group.

Early pubertal maturation may lead to low physical activity for a variety of reasons including both intrapersonal factors (e.g., body esteem, depression, and perceived skill) and interpersonal factors (e.g., parent and peer support). With regard to intrapersonal factors, early maturing girls have been found to have poorer body image than their later maturing peers (Graber, Brooks-Gunn, & Warren, 1999), which has been identified as a constraint to both participation in and enjoyment of leisure activities (Frederick & Shaw, 1995; James, 2000). Earlier maturing girls may be reluctant to participate in physical activity in settings they feel draw attention to their bodies. Higher levels of depression exhibited by early maturing girls (Motl, Birnbaum, Kubik, & Dishman, 2004) may also decrease girls' motivation for engaging in physical activity. In addition to decreasing girls' motivation for physical activity, the physical changes of puberty may impact girls' ability to participate in physical activity. For example, breast development may directly reduce spontaneous physical activity due the need for appropriate clothing. Furthermore, puberty-related changes put girls at a performance disadvantage in some sports (Malina & Bouchard, 1991). As a result, earlier maturing girls may self-select out of sports because they are less skilled than their later maturing peers (Malina & Bouchard, 1991).

Early maturing girls may also decrease their physical activity during adolescence as a result of changes in interpersonal factors such as interactions with parents and peers. Parent-daughter relationships change significantly during puberty. Parents, particularly fathers, may be uncomfortable with the changes in their daughter's body (Paikoff & Brooks-Gunn, 1991). Along similar lines, early maturing girls report that adults expect them to behave more maturely (Paikoff & Brooks-Gunn, 1991). This combination of parental discomfort regarding their daughter's more mature body and their tendency to encourage more adult behaviors may result in parents providing less support for “child-like” activities such as playing outdoors and more encouragement for less physically strenuous activities that are perceived as more feminine. While parental support is important throughout childhood and into adolescence(Stewart G. Trost et al., 2003), peers become increasingly influential during this developmental period(Smith, 1999). Research shows that earlier maturing girls tend to associate with an older peer group (Caspi & Moffit, 1991). Given the general decline in physical activity with age in adolescence (Thompson, Baxter-Jones, Mirwald, & Bailey, 2003), earlier maturing girls are likely to belong to a peer group that is less active than their age cohort. In sum, there is a broad range of factors that may explain the link between pubertal timing and physical activity including intrapersonal and interpersonal factors which warrant future investigation.

This study has a number of strengths and weaknesses. The longitudinal design of the study allowed the examination of the effect of pubertal timing among young adolescent girls (at age 11) on their physical activity levels 2 years later (at age 13) controlling for physical activity levels at age 11. Additional strengths include the use of multiple measures of pubertal development to classify pubertal timing and the use of an objective measure of physical activity. While the study design and measures used were strengths of this study, there were also several limitations. Participants in the study were primarily Caucasian girls residing in central Pennsylvania. Therefore, results may not generalize across geographic areas or ethnicities. It is possible that very different associations would be identified between pubertal timing and physical activity among other ethnic groups given differences ethnic differences in pubertal timing (Herman-Giddens et al., 1997), ideal body shape (Siegel, Yancey, Aneshensel, & Schuler, 1999), and baseline physical activity (National Center for Health Statistics, 2005). An additional limitation is the use of a self-report measure of physical activity at age 11 (objective monitoring was not available at age 11) for which relatively little measurement work has been done. Differences in physical activity between earlier and later maturing girls may have existed at age 11 but the self-report physical activity measure may not have been sensitive enough to detect them. Finally, the measurement of pubertal development resulted in limitations. Due to the limited age span that was assessed, it was not possible to separate the effects of early pubertal timing from pubertal development per se due. In addition, because two of the three variables used to measure pubertal status were not assessed at age 13, potential relationships between tempo of pubertal timing and physical activity could not be explored.

Future research can build on findings from this study in a number of ways. The availability of longitudinal data on girls across a broader age span such as 10 to 16 years will enable researchers to determine whether all girls similarly exhibit a drop-off in physical activity as they experience puberty or whether early maturing girls are at particular risk of such a decline. Extended longitudinal data will also enable us to determine whether such a drop off is temporary or is maintained throughout adolescence. In order to effectively guide intervention efforts, future research could also assess potential mechanisms linking pubertal timing and physical activity, some of which were reviewed above. Although results from this study do not directly speak to the mechanisms that may lead early girls to disengage from physical activity, they highlight that early maturing girls are at risk of low physical activity and that individuals interacting with adolescent girls such as doctors, teachers, parents and coaches should be aware of this fact and seek ways to maintain girls' interest in physical activity as they transition through puberty.

Acknowledgements

This research was funded by NIH grants to Birch, L.L. (HD 32973, M01 RR10732) and Davison, K.K. (HD 46567-01). We would like to thank Dorothy Schmalz for her valuable assistance in collecting the data and the families who have participated in this study since the girls were 5 years old.

Table 2.1: Measures of pubertal status at age 11 for girls classified as earlier or later maturing

Measure	Maturational Timing (age 11)		T- value	P-value
	Earlier maturation (N = 41)	Later maturation (N = 102)		
Mean Estradiol (pg/mL)	12.51 (7.42)	4.21 (3.74)	3.89	<.001
Mean PDS	2.51 (0.36)	1.77 (0.37)	4.66	<.001
Mean Breast Development Stage	2.83 (0.74)	2.00 (0.61)	2.96	<.001
Breast Development Stage 1 (%)	0%	15%		
Breast Development Stage 2 (%)	34%	73%		
Breast Development Stage 3 (%)	51%	9%		
Breast Development Stage 4 (%)	12%	3%		
Breast Development Stage 5 (%)	3%	0%		

Table 2.2: Mean(sd) scores for BMI, percentage body fat and physical activity for earlier and later maturing girls at ages 11 and 13

Age	Measure	Maturational Timing (age 11)		T- value	P-value
		Earlier maturation (N = 41)	Later maturation (N = 102)		
11	Weight (kg)	51.26 (13.95)	42.04 (8.88)	3.89	<.001
	Height (cm)	152.6 (6.82)	146.93 (6.32)	4.66	<.001
	BMI	21.86 (4.77)	19.37 (3.22)	2.96	.005
	BMI z-score	.92 (.88)	.37 (.91)	3.21	.002
	Percentage Body Fat	30.15 (6.80)	27.47 (6.89)	2.06	.042
	Self-reported PA	2.98 (.35)	2.90 (.35)	-1.15	.254
13	Weight (kg)	61.65 (16.68)	52.86 (10.99)	3.02	.004
	Height (cm)	161.57 (6.78)	159.66 (6.22)	1.47	.144
	BMI	23.53 (5.65)	20.63 (3.77)	2.96	.004
	BMI z-score	.89 (.85)	.30 (.92)	3.47	<.001
	Percentage Body Fat	30.81 (6.15)	26.00 (6.77)	3.63	. <.001
	Self report PA	2.64 (.40)	2.84 (.39)	2.68	.008
	MPA (avg min/day)	28.18 (10.04)	32.96 (12.19)	-2.20	.028
	MVPA (min/day)	30.83 (11.62)	37.80 (15.90)	-2.94	.004
	VPA (min/day)	2.65 (2.19)	4.87 (4.61)	-3.89	<.001
	Accelerometer counts per day	326515 (81126)	375039 (99912)	-2.84	.003

Note: MPA = moderate physical activity, MVPA = moderate to vigorous physical activity, VPA = vigorous physical activity; MPA, MVPA and VPA were assessed using accelerometers.

Table 2.3: Results from regression analyses using pubertal timing at age 11 to predict physical activity at age 13 controlling for physical activity, percent body fat,and SES at age 11

Outcome at age 13	Independent variable (IV) and covariates (cov) at age 11	b	β	p-value
Moderate to Vigorous PA	Intercept	22.22		.134
	Self-reported PA (cov)	6.46	.150	.108
	Percentage body fat (cov)	-0.11	-.049	.607
	SES (cov)	-.15	-.014	.875
	Early pubertal timing (IV)	-6.07	-.202	.025
Vigorous PA	Intercept	-2.85		.492
	Self-reported PA (cov)	3.01	. 241	.008
	Percentage body fat (cov)	-.03	-.055	.556
	SES (cov)	.26	.085	.338
	Early pubertal timing (IV)	-2.17	-.230	.009
Accelerometer counts/day	Intercept	226636		.018
	Self-reported PA (cov)	51249	.184	.048
	Percentage body fat (cov)	-61	-.004	.964
	SES (cov)	-2211	-.032	.727
	Early pubertal timing (IV)	-45440	-.215	.016

Note: b = unstandardized beta weight; β = standardized beta weight; PA = physical activity

References

Allison, K. R., Adlaf, E. M., Irving, H. M., Hatch, J. L., Smith, T. F., Dwyer, J. M., et al. (2005). Relationship of vigorous physical activity to psychologic distress among adolescents. *Journal of Adolescent Health, 37*(2), 164.

Caspersen, C. J., Pereira, M. A., & Curran, K. M. (2000). Changes in physical activity patterns in the United States, by sex and cross-sectional age. *Medicine and Science in Sports and Exercise, 32*(9), 1601-1609.

Caspi, A., & Moffit, T. E. (1991). Individual differences are accentutated during periods of social change: The sample case of girls at puberty. *Journal of Personality and Social Psychology, 61*(1), 157-168.

Ellis, K. J., Shypailo, R. J., Pratt, J. A., & Pond, W. G. (1994). Accuracy of dual-energy x-ray absorptiometry for body-composition measurements in children. *American Journal of Clinical Nutrition, 60*, 660-665.

Frederick, C. J., & Shaw, S. M. (1995). Body image as a leisure constraint: Examining the experience of aerobic exercise classes for young women. *Leisure Sciences, 17*, 57-73.

Freedson, P. S., Pober, D., & Janz, K. F. (2005). Calibration of accelerometer output for children. *Medicine and Science in Sports and Exercise, S37*(11), S523-530.

Goran, M. I., Driscoll, P., Johnson, R., Nagy, T. R., & Hunter, G. (1996). Cross-calibration of body-composition techniques against dual-energy X-ray absorptiometry in young children. *American Journal of Clinical Nutrition, 63*, 299-305.

Graber, J. A., Brooks-Gunn, J., & Warren, M. P. (1999). The vulnerable transition: Puberty and the development of eating pathology and negative mood. *Women's Health Issues, 9*(2), 107-114.

Hale, D. E. (2004). Type 2 diabetes and diabetes risk factors in children and adolescents. *Clinical Cornerstone, 6*(2), 17-30.

Herman-Giddens, M. E., Slora, E. J., C, W. R., Bourdony, C. J., Bhapkar, M. V., Koch, G. G., et al. (1997). Secondary sexual characteristics and menses in young girls seen in office practice: A study from the Pediatric Research in Office Settings network. *Pediatrics, 99*(4), 505-512.

Jago, R., Anderson, C. B., Baranowski, T., & Watson, K. (2005). Adolescent patterns of physical activity differences by gender, day, and time of day. *American Journal of Preventive Medicine, 28*(5), 447-452.

James, K. (2000). "You can feel them looking at you": The experiences of adolescent girls at swimming pools. *Journal of Leisure Research, 32*(2), 262-280.

Kuczmarski, R. J., Kuczmarski, M. F., & Roche, A. F. (2002). 2002 CDC growth charts: Background for clinical application. *Topics in Clinical Nutrition, 17*(2), 15-27.

Lanza, S. T., & Collins, L. M. (2002). Pubertal timing and the onset of substance use in females during early adolescence. *Prevention Science, 3*(1), 69-82.

Loucks, A. B. (2003). Energy availability, not body fatness, regulates reproductive function in women. *Exercise and Sport Sciences Reviews, 31*(3), 144-148.

Lukaski, H. C. (1993). Soft tissue composition and bone mineral status: Evaluation by dual-energy X-ray absorptiometry. *The Journal of Nutrition, 123*(2), 438-443.

Ma, H., Bernstein, L., Pike, M. C., & Ursin, G. (2006). Reproductive factors and breast cancer risk according to joint estrogen and progesterone receptor status: A meta-analysis of epidemiological studies. *Breast Cancer Reearchs, 8*(4), R43.

Malina, R. M., & Bouchard, C. (1991). *Growth, maturation, and physical activity*. Champaign, IL: Human Kinetics.

Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). *Growth, maturation, and physical activity* (2nd ed.). Champaign, IL: Human Kinetics.

Marshall, W. A., & Tanner, J. M. (1969). Variations in the pattern of pubertal changes in girls. *Archives of Diseases in Children, 44*, 291-303.

Masse, L. C., Fuemmeler, B. F., Anderson, C. B., Matthews, C. E., Trost, S. G., Catellier, D. J., et al. (2005). Accelerometer data reduction: a comparison of four reduction algorithms on select outcome variables. *Medicine and Science in Sports and Exercise, 37*(11 Suppl), S544-554.

Mazess, R. B., Barden, H. S., Bisek, J. P., & Hanson, J. (1990). Dual-energy x-ray absorptiometry for total-body and regional bone-mineral and soft-tissue composition. *American Journal of Clinical Nutrition, 51*(6), 1106-1112.

McCabe, M. P., & Ricciardelli, L. A. (2004). A longitudinal study of pubertal timing and extreme body change behaviors among adolescent boys and girls. *Adolescence, 39*(153), 145-166.

Michaud, P. A., Suris, J. C., & Deppen, A. (2006). Gender-related psychological and behavioural correlates of pubertal timing in a national sample of Swiss adolescents. *Molecular Cell Endocrinology, 254-255*, 172-178.

Motl, R. W., Birnbaum, A. S., Kubik, M. Y., & Dishman, R. K. (2004). Naturally occurring changes in physical activity are inversely related to depressive symptoms during early adolescence. *Psychosomatic Medicine, 66*(3), 336-342.

National Center for Health Statistics. (2005). *Health, United States, 2005 With Chartbook on Trends in the Health of Americans* Hyattsville, Maryland: National Center for Health Statistics.

Nilsson, A., Ekelund, U., Yngve, A., & Sjostrom, M. (2002). Assessing physical activity among children with accelerometers using different time sampling intervals and placements. *Pediatric Exercise Science, 14*, 87-96.

Paikoff, R. L., & Brooks-Gunn, J. (1991). Do parent-child relationships change during puberty? *Psychological Bulletin, 110*(1), 47-66.

Pan, S. Y., Ugnat, A. M., & Mao, Y. (2005). Physical activity and the risk of ovarian cancer: A case-control study in Canada. *International Journal of Cancer, 117*(2), 300-307.

Peterson, A. C., Crockett, L., Richards, M., & Boxer, A. (1988). A self-report measure of pubertal status: Reliability, validity, and initial norms. *Journal of Youth and Adolescence, 17*, 117-133.

Peterson, A. C., Tobin-Richards, M., & Boxer, A. (1983). Puberty: Its measurement and its meaning. *Journal of Early Adolescence, 3*, 47-62.

Roemmich, J. N., Richmond, R. J., & Rogol, A. D. (2001). Consequences of sport training during puberty. *Journal of Endocrinological Investigation, 24*(9), 708-715.

Rogol, A. D., Clark, P. A., & Roemmich, J. N. (2000). Growth and pubertal development in children and adolescents: Effects of diet and physical activity. *American Journal of Clinical Nutrition, 72*(2 Suppl), 521S-528S.

Shantakumar, S., Terry, M. B., Teitelbaum, S. L., Britton, J. A., Millikan, R. C., Moorman, P. G., et al. (2006). Reproductive factors and breast cancer risk among older women. *Breast Cancer Research and Treatment.*

Shirtcliff, E. A., Granger, D. A., Schwartz, E. B., Curran, M. J., Booth, A., & Overman, W. H. (2000). Assessing estradiol in biobehavioral studies using saliva and blood spots: Simple radioimmunoassay protocols, reliability, and comparative validity. *Hormonal Behavior, 38*, 137-147.

Siegel, J. M., Yancey, A. K., Aneshensel, C. S., & Schuler, R. (1999). Body image, perceived pubertal timing, and adolescent mental health. *Journal of Adolescent Health*, *25*(2), 155-165.

Simon, A. E., Wardle, J., Jarvis, M. J., Steggles, N., & Cartwright, M. (2003). Examining the relationship between pubertal stage, adolescent health behaviors and stress. *Psychological Medicine*, *33*(8), 1369-1379.

Smith, A. L. (1999). Perceptions of peer relationships and physical activity participation in early adolescents. *Journal of Sport and Exercise Psychology, 21*, 329-350.

Spear, B. A. (2002). Adolescent growth and development. *Journal of the American Dietetic Association, 102*(3), S23-S29.

Thompson, A. M., Baxter-Jones, A. D., Mirwald, R. L., & Bailey, D. A. (2003). Comparison of physical activity in male and female children: Does maturation matter? *Medicine and Science in Sports and Exercise, 35*(10), 1684-1690.

Torstveit, M. K., & Sundgot-Borgen, J. J. (2005). Participation in leanness sports but not training volume is associated with menstrual dysfunction: a national survey of 1276 elite athletes and controls. *British Journal of Sports Medicine*, *39*(3), 141-147.

Tremblay, L. L., & Frigon, J. Y. (2005). The interaction role of obesity and pubertal timing on the psychosocial adjustment of adolescent girls: longitudinal data. *International Journal of Obesity*, *29*(10), 1204-1211.

Trost, S. G., Kerr, L. M., Ward, D. S., & Pate, R. R. (2001). Physical activity and determinants of physical activity in obese and non-obese children. *International Journal of Obesity and Related Metabolic Disorders, 25*(6), 822-829.

Trost, S. G., McIver, K. L., & Pate, R. R. (2005). Conducting accelerometer-based activity assessments in field-based research. *Medicine and Science in Sports and Exercise, 37*(11 Suppl), S531-543.

Trost, S. G., Pate, R. R., Sallis, J. F., Freedson, P. S., Taylor, W. C., Dowda, M., et al. (2002). Age and gender differences in objectively measured physical activity in youth. *Medicine and Science in Sports and Exercise, 34*, 350-355.

Trost, S. G., Sallis, J. F., Pate, R. R., Freedson, P. S., Taylor, W. C., & Dowda, M. (2003). Evaluating a model of parental influence on youth physical activity. *American Journal of Preventive Medicine, 25*(4), 277-282.

Trost, S. G., Ward, D. S., Moorehead, S. M., Watson, P. D., Riner, W., & Burke, J. R. (1998). Validity of the computer science and applications (CSA) activity monitor in children. *Medicine and Science in Sports and Exercise, 30*(4), 629-633.

Tucker, L. A., Seljaas, G. T., & Hager, R. L. (1997). Body fat percentage of children varies according to their diet composition. *Journal of the American Dietetic Association, 97*(981-986).

Velie, E. M., Nechuta, S., & Osuch, J. R. (2005). Lifetime reproductive and anthropometric risk factors for breast cancer in postmenopausal women. *Breast Diseases, 24*, 17-35.

Orientation to Chapter 3

This chapter is a manuscript that will be submitted to *The Journal of Leisure Research* for publication. The purpose of this chapter is to examine predictors of levels of intrinsic and extrinsic motivation across ages 9-13 and the relationship type of motivation and physical activity using a SDT framework. The following hypotheses are tested:

H1: Level of extrinsic motivation for physical activity across ages 9 to 13 is predicted by perceived athletic competence (negative), parental encouragement of autonomy (negative), and quality of relationship with parents (negative) at age 9.

H2: Level of intrinsic motivation for physical activity across ages 9 to 13 is predicted by perceived athletic competence (positive), parental encouragement of autonomy (positive), and quality of relationship with parents (positive) at age 9.

H3: Girls with consistently high levels of intrinsic motivation have higher levels of physical activity at age 13 than do other girls.

H4: Girls with consistently high levels of extrinsic motivation do not have higher levels of physical activity at age 13 than do other girls.

CHAPTER 3

WEIGHT-RELATED AND ENJOYMENT-RELATED PHYSICAL ACTIVITY MOTIVATION IN ADOLESCENT GIRLS: A TEST OF SELF-DETERMINATION THEORY

Abstract

Research with adolescents has indicated that individuals who are intrinsically motivated are more likely to engage in leisure time physical activity than those who are extrinsically motivated. Based on predictions of Ryan and Deci's (2000) Self-Determination Theory (SDT), this study examines physical activity motivation in a sample of 135 adolescent girls across ages 9-13. Congruent with SDT, relatedness (a sense of connection to others), perceived competence (a belief in one's ability to accomplish a task), and autonomy (a sense of independence and freedom from external compulsion) were examined as predictors of intrinsic and extrinsic motivation. In addition, intrinsic motivation is a stronger predictor of behavior than is extrinsic motivation. In this study, girls' perceptions of their athletic competence, quality of their relationship with their parents, and parental support for autonomy were assessed as predictors of intrinsic (fun) and extrinsic (weight-related) motivation for physical activity. A sample of 135 adolescent girls was assessed at ages 9, 11, and 13. Measures of perceived athletic competence, parental encouragement of autonomy, quality of relationship with parents, and percent body fat were obtained at age 9. Measures of intrinsic and extrinsic activity motivation were obtained at ages 9, 11, and 13. Moderate-to-vigorous physical activity (MVPA) was measured using accelerometers at age 13. Dichotomized variables for intrinsic and extrinsic motivation were created in which girls with consistently high levels of intrinsic/extrinsic motivation for physical activity were

contrasted against those who did not report levels that were consistently above average across ages 9-13. Results indicate that age 9 perceived athletic competence and parental encouragement of autonomy were significant positive predictors of persistent intrinsic motivation across ages 9-13 and significant negative predictors of persistent extrinsic motivation across ages 9-13. Persistent intrinsic motivation, but not extrinsic motivation, across ages 9-13 was, in turn, a significant positive predictor of age 13 MVPA. These results are congruent with Self-Determination Theory and suggest that environments that foster choice, skill-development, and enjoyment are optimal for promoting physical activity.

Introduction

US adolescents spend an average of 6-8 hours per day in discretionary or 'free time' activities (Larson & Seepersad, 2003; Zick, 2007), making leisure an important developmental context. Leisure is unique among adolescent contexts in its affordance of self-directed behavior (Darling, Caldwell, & Smith, 2005) and its opportunities for identity exploration (Sharp, Caldwell, Graham, & Ridenour, 2006). Within this relatively autonomous context, there is considerable variation in the ways in which youth choose to spend their time and much of it is taken up with activities that are unlikely to promote positive development (Sharp et al., 2006). For example, US adolescents spend an average of 1.5-2.5 hours per day watching television (Larson & Seepersad, 2003) and less than 32 minutes per day of moderate-to-vigorous physical activity (MVPA).

Physical activity is associated with a variety of positive mental and physical health outcomes for children and adolescents. Unfortunately, girls are particularly likely to have low levels of physical activity. Less than 5% of adolescent girls meet the recommendations of 60 minutes or more of MVPA per day (Troiano et al., 2008). Given that only 2% of adolescents' time is spent in physical education classes and only 16% of this time is spent in MVPA (Vierling, Standage, & Treasure, 2007), the majority of adolescent physical activity occurs outside of school in a leisure setting (Ross, Dotson, Gilbert, & Katz, 1985). Research has demonstrated a relationship between type of motivation and participation in physical activity (Haverly & Davison, 2005; Ntoumanis, 2005)and leisure environments are likely to be characterized by intrinsic motivation (Godbey, Caldwell, Floyd, & Payne, 2005; Larson, 2000). Given the low levels of physical activity in adolescent girls and the relationship between motivation and physical activity, the purpose of this study is to examine predictors and outcomes of motivation for physical activity in adolescent girls.

Self-determination Theory

Self-Determination Theory (SDT; Deci & Ryan, 2000) has emerged as a paradigm for examining motivations for exercise (Edmunds, Ntoumanis, & Duda, 2006) and leisure behaviors (Baldwin & Caldwell, 2003; Godbey, Caldwell, Floyd, & Payne, 2005). Ryan and Deci (2000) place three types of motivation on a continuum ranging from amotivation (least self-determined) through extrinsic motivation to intrinsic motivation (most self-determined).

Amotivation, as the name implies, is the absence of motivation and results in either no action or purposeless action (Ryan & Deci, 2000). Extrinsic motivation differs from amotivation in that it results in purposive action and is characterized by forces external to enjoyment of the activity itself. Individuals may be motivated by external reward/punishment (eg. a girl exercises because her parents have agreed to buy her new clothes if she loses 10 pounds), guilt or pride (eg. a girl exercises because she feels she has eaten too much and will feel guilty if she does not burn off the calories), or because she values outcomes associated with the behavior (eg. a girl exercises because she feels that being healthy is important). In contrast to extrinsic motivation, intrinsic motivation is characterized by an autotelic experience (Csikszentmihalyi, 1991) in which the activity is performed for its own sake rather than as a result of external compulsions or rewards. Individuals who engage in physical activity for intrinsic reasons, such as fun, are more likely to initiate and sustain the activity (Gillison, Standage, & Skevington, 2006). While the types of motivation are conceptualized as existing on a continuum, research has indicated that individuals may have both intrinsic and extrinsic motivation for a given activity (Standage, Duda, & Ntoumanis, 2003). In the case of physical activity, an individual may exercise both because she enjoys running and because she appreciates the weight-control benefits of physical activity.

Intrinsically motivated behaviors are more likely to be initiated and maintained than are extrinsically motivated behaviors (Ryan & Deci, 2000). Therefore, positive behaviors such as physical activity may be facilitated by increasing intrinsic motivation. In order to promote intrinsic motivation, we must understand the conditions under which changes in motivation occur. In describing the precursors of type of motivation, Deci and Ryan (2000) posit that perceived competence, relatedness, and autonomy are fundamental human needs, the fulfillment of which is a prerequisite for intrinsic motivation. Perceived competence refers to a person's belief that he/she can perform the behaviors necessary to be successful in a given domain (Bandura, 1997; Ryan & Deci, 2000). Relatedness is a person's feelings of connection to valued individuals (Deci & Ryan, 2000). Autonomy refers to a person's feelings of freedom from compulsion or coercion (Deci & Ryan, 2000). Autonomy is sometimes incorrectly conceptualized as the severing of emotional bonds and therefore as the antithesis of relatedness (Grotevant, 1998). Autonomy and relatedness are not, however, incompatible and well functioning systems promote both individuality and intimacy (Gavazzi, 1993).

An environment that fulfills needs for relatedness and competence permits the development of extrinsic motivations but fulfillment of the need for autonomy is required for the emergence of intrinsic motivation (Ryan & Deci, 2006). Thus, according to Self-Determination Theory, girls are likely to have intrinsic motivation when they perceive themselves as competent and experience support for both autonomy and relatedness. Conversely, extrinsic motivation is likely to be predicted by lower perceived competence and relatedness and a lack of autonomy.

Motivation for Physical Activity among Adolescent Girls

Much of the research on motivation for physical activity has occurred in a physical education (PE) setting. Research in this context has indicated that individuals with higher intrinsic motivation report higher effort (Ferrer-Caja & Weiss, 2000), lower boredom (Ntoumanis, 2001), and greater intent to be physically active during their leisure time (Standage, Duda, & Ntoumanis, 2003). In addition, greater intrinsic motivation is associated with a higher probability of enrolling in optional PE the next year (Ntoumanis, 2005) and of engaging in an activity initiated in PE during leisure time (Vansteenkiste, Simons, Soenens, & Lens, 2004). Conditions associated with intrinsic motivation in PE class participants included environments which supported choice (Ntoumanis, 2005; Prusak, Treasure, Darst, & Pangrazi, 2004), encouraged students to judge their performance based on individual improvement rather than others' performance (Ntoumanis & Biddle, 1999), provided a sense of competence (Ferrer-Caja & Weiss, 2000; Ntoumanis 2005; Standage et al., 2003), and facilitated a sense of connectedness with others (Ntoumanis 2005; Standage et al., 2003).

Research in non-PE settings has yielded similar results. In studies of overall physical activity, organized afterschool programming, and youth sport, intrinsic motivation has been associated with lower dropout (Sarrazin, Roberts, Cury, Biddle, & Famose, 2002)and higher levels of physical activity (Vierling, Standage, & Treasure, 2007; Wilson & Rodgers, 2004). As with a PE context, intrinsic motivation was predicted by environments that facilitated perceptions of choice, connectedness, and competence (Vierling, Standage, & Treasure, 2007; Wilson & Rodgers, 2004). This literature in this area has not, however, examined motivation for physical activity across several years or the influence of parental autonomy granting and relatedness.

Goals of the study

The purpose of this paper is to investigate predictors and outcomes of levels of intrinsic and extrinsic motivation for physical activity across ages 9, 11, and 13 (see Figure 1). Consistent with previous research, intrinsic motivation is operationalized as enjoyment related motivation (Ryan & Deci, 2006). In contrast, extrinsic motivation is characterized by motives other than enjoyment. One type of extrinsic motivation for physical activity that is likely to be particularly salient for adolescent girls is the desire to lose weight or keep from gaining weight. Weight concerns increase as puberty-related changes cause increases in fat mass (Monsma, Malina, & Feltz, 2006) and weight-related activity motivation may increase concurrently. Therefore, this study will focus on physical activity for the purpose of weight loss as form of extrinsic motivation.

Adolescent motivation has not, to our knowledge been studied longitudinally across several years in a physical activity context. Intrinsic motivation for free time (Sharp, Caldwell, Graham, & Ridenour, 2006) and academic (Eccles & Wigfield, 2002) activities declines during the middle school years. In a free time context, individuals who exhibited higher levels of intrinsic motivation at each time-point were less likely to experience boredom during their leisure time (Sharp et al., 2006). Therefore, this study will examine predictors and outcomes of persistent levels of intrinsic and extrinsic motivation across ages 9-13.

Based on SDT and previous research on adolescent motivation (as shown in Figure 1), we hypothesized that perceived athletic competence, parental encouragement of autonomy, and quality of relationship with parents at age 9 are significant positive predictors of consistently high levels of intrinsic motivation and significant negative predictors of consistently high levels of extrinsic (weight related) motivation across ages 9 to 13. In addition, we predicted that girls with consistently high levels of intrinsic motivation will have higher levels of physical activity at age 13 than will other girls, while levels of extrinsic motivation will not be predictive of age 13 physical activity.

Methods

Participants

Participants were 135 adolescent non-Hispanic white girls who were part of a longitudinal study examining girls' nutrition, dieting, physical activity, and health. Approval for research involving human participants was obtained from the Institutional Review Board at the Pennsylvania State University. Data were collected when the girls were ages 9 (mean=9.32, sd= .29), 11 (mean=11.32, sd= .29), and 13 (mean=13.31, sd= .27) years. Parents and the participants provided written informed consent for all procedures. Participants visited the laboratory at the university where they completed a variety of questionnaires and a variety of anthropometric and biological measures were obtained. Participants also wore accelerometers for one week.

Measures

Measures of perceived athletic competence, parental encouragement of autonomy, quality of relationship with parents, girls' weight status, and family socioeconomic status (SES) were collected at age 9. Physical activity motivation was measured at ages 9, 11, and 13. Girls' physical activity was measured using accelerometers at age 13.

Motivation for physical activity. Motivation for physical activity was measured using items from the Girls' Activity Motivation Scale (GAMS). This scale was created for the larger longitudinal study. It consists of 22 items to which the participant responds on a scale of one to four whether or not she plays sports or exercises for that reason. Extrinsic motivation was measured using a three-item scale at each time point. The items in the scale were: I exercise/play sports: 1) to lose weight; 2) because I think I look fat; and 3) to make sure I don't get fatter. Alpha values for the extrinsic scale were α=.77 at age 9, α=.80 at age 11 and α=.84 at age 13. Intrinsic motivation was measured at each time using a single item; I exercise/play sports because it is fun. Extrinsic motivation was significantly positively skewed at all three time points as many girls reported low levels of weight-related motivation. Conversely, intrinsic motivation was significantly negatively skewed at all three time points as many girls indicated that fun was a strong motivation for physical activity. Therefore, intrinsic and extrinsic motivation were treated as dichotomous variables. Scores on each type of motivation were dichotomized at each time point using the mean for that time point as the division. For each type of motivation, two groups were then created based on their scores at all three times. Girls who reported above average levels of motivation at all three time points were identified as having high persistent intrinsic/extrinsic motivation while the remaining girls were identified as having lower persistent intrinsic motivation.

Perceived athletic competence. Perceived athletic competence was measured using the athletic competence subscale of the Self - Perception Profile for Children (Harter, 1985). This subscale consists of 6 items which present the respondent with descriptions of two children and ask her to indicate which is most like her and whether the child she selected is 'a little like her' or 'a lot like her'. Higher scores on this subscale indicate higher perceived competence. In this sample, the internal consistency co-efficient was α=.80 at age 9 indicating acceptable internal reliability.

Autonomy. The Feeling Controlled subscale from Kerr and Stattin's (2000) Autonomy Granting scale was used to measure perceived autonomy. This is a five item measure of the degree to which a child feels controlled by her parents. Higher scores on this measure corresponded with higher perceived autonomy. Previous research has yielded an alpha value of $\alpha = .82$ for this subscale indicating acceptable internal consistency (Kerr & Stattin, 2000). In this sample, the internal consistency co-efficient was α=.73 at age 9.

Relatedness. Connection to valued others (relatedness) was measured using participants' perceptions of their relationships with their parents. The Relationship with Parents subscale from Kerr and Stattin's (2000) Autonomy Granting scale was used to measure this construct. This scale is a sixteen-item measure of the child's perception of the quality of her relationship with her parents. Previous research has yielded alpha values ranging from $\alpha = .82$ to $\alpha = .85$ for this subscale, indicating acceptable internal consistency (Kerr & Stattin, 2000). In this sample, the internal consistency co-efficient was α=.84 at age 9.

Girls' objectively-measured physical activity. Objective assessments of physical activity were obtained using the ActiGraph 7164 accelerometer (Shalimar, FL). This instrument provides a valid and reliable source of information regarding physical activity when at least four days of monitoring are used (Trost, McIver, & Pate, 2005; Trost et al., 1998). The ActiGraph is a uniaxial accelerometer designed to detect vertical accelerations ranging in magnitude from 0.05 to 2.00 G's with a frequency response of 0.25 – 2.50 Hz. These parameters allow for the detection of normal human motion and will reject high frequency vibrations encountered during activities such as operation of a lawn mower. The filtered acceleration signal is digitized, rectified, and integrated over a user-specified epoch interval. At the end of each epoch, the summed value or "activity count" is stored in memory and the integrator is reset. For the current study, a 30 s epoch was used. The Actigraph 7164 has been shown to be a valid and reliable tool for assessing physical activity in children and adolescents (Trost et al., 1998).

After receiving detailed instructions regarding the care and use of the accelerometers, girls were instructed to wear the ActiGraph at all times, except when bathing and swimming, for 7 consecutive days. Consistent with previous studies, the ActiGraph was worn on the right hip (mid-axilla line at the level of the iliac crest). Non-wearing time for each monitoring day was calculated by counting the number of zero counts accumulated in strings of 20 minutes or longer. Girls were included in the analyses if they had 4 or more days with 10 or more hours of wearing time (Mâsse et al., 2005). In this study, 75.2% of girls had 7 valid monitoring days, with 14.3%, 6.8%, and 3.8% providing 6, 5, and 4 valid days, respectively. Among the participants with 4 or more valid monitoring days, daily wear time ranged from 763.4 minutes to 1282 minutes, with an average of 1086 ± 116 minutes.

Raw accelerometer counts were uploaded to a customized software program for determination of total daily counts, and daily time spent in moderate (MPA), vigorous (VPA), and moderate-to-vigorous (MVPA) physical activity. The age-specific count thresholds corresponding to the aforementioned intensity levels were derived from the MET prediction equation developed by Freedson and co-workers (Freedson, Pober, & Janz, 2005; Trost et al., 2002). To accommodate the 30-sec epoch length, count thresholds were divided by 2 (Nilsson, Ekelund, Yngve, & Sjostrom, 2002).

Percent Body Fat. Dual-energy X-Ray absorptiometry (DXA) was used to measure girls' percent body fat. Whole body scans were done using the Hologic QDR 4500W (S/N 47261) in the array scan mode and analyzed using whole body software, QDR4500 Whole Body Analysis. DXA has received widespread use and is the preferred method of assessing body composition among children, because it provides an accurate, reliable, and non-invasive means of quantifying bone mineral content and body mass content, including fat and lean mass, while minimizing radiation exposure during measurement (Ellis, Shypailo, Pratt, & Pond, 1994; Goran, Driscoll, Johnson, Nagy, & Hunter, 1996; Lukaski, 1993; Mazess, Barden, Bisek, & Hanson, 1990).

Socioeconomic status (SES). Parents reported their education levels and family income when the girls were 9 years old. A composite measure of family SES status was created using principal components analysis of mother's education, father's education, and family income.

Statistical Analyses

Analyses for this paper were conducted using SPSS version 14.0. The model outlined in Figure 1 was tested using logistic regression and multiple linear regression in a two step process. First, multivariate logistic regressions were run to test the hypothesis that perceived athletic competence, parental encouragement of autonomy, and quality of relationship with parents at age 9 are significant negative predictors of consistently high levels of extrinsic (weight related) motivation and significant positive predictors of consistently high levels of intrinsic motivation across ages 9 to 13. Body fat percentage and SES at age 9 were entered as covariates.

Second, linear regression was used to test the hypothesis that girls with consistently high levels of intrinsic motivation will have higher levels of physical activity at age 13 than will other girls while levels of extrinsic motivation will not be predictive of age 13 physical activity. Dichotomized level of persistent intrinsic and extrinsic motivation were entered into a regression equation predicting average minutes of moderate to vigorous physical activity per day. Body fat percentage, SES, and self-report physical activity at age 11 were entered as covariates.

Results

Descriptive statistics

Sixteen percent of girls in this sample lived in households with incomes of less than \$35,000. Twenty-nine percent had household incomes between \$35,000 and \$50,000 and the remaining 55 percent had household incomes above $50,000. Average scores of the variables of interest in this study are detailed in Table 1. Scores on intrinsic motivation were generally high while scores on extrinsic motivation were generally low. The grouping of girls based on their levels of motivation at all three times resulted in 25 girls in the consistently high persistent extrinsic motivation group and 110 girls in the lower persistent extrinsic motivation group. The consistently high persistent intrinsic motivation group contained 82 girls while the lower persistent intrinsic motivation group contained 53 girls.

Testing the Proposed Model

Predictors of extrinsic motivation. As predicted perceived autonomy (OR = .355; 95% C.I. = .169 - .744), and perceived competence (OR = .352; 95% C.I. = .142- .871) were negative predictors, while percent body fat was a positive predictor (OR = 1.142, 95% C.I. = 1.052-1.239) of extrinsic motivation (See Table 2). Contrary to expectations, perceived relatedness was not significantly associated with extrinsic motivation. These results were independent of SES. The odds of a girl being persistently extrinsically motivated decreased by a factor of .35 for every one unit increase in perceived competence or autonomy, while the odds of being consistently extrinsically motivated increased by a factor of 1.142 for every one percent increase in body fat percentage.

Predictors of intrinsic motivation. As predicted, perceived competence (OR = 2.011; 95% C.I. = 1.050 - 3.848) and perceived autonomy (OR = 1.937; 95% C.I. = 1.116 - 3.362) were positive predictors of intrinsic motivation (See Table 3). Contrary to expectations, perceived relatedness was not significantly associated with intrinsic motivation. The odds of a girl being persistently intrinsically motivated increased by a factor of 2.011 for every one unit increase in perceived competence and by a factor of 1.937 for every one unit increase in perceived autonomy.

Intrinsic and extrinsic motivation as predictors of MVPA. Persistent intrinsic motivation was a significant positive predictor of age 13 MVPA controlling for age 11 body fat percentage, SES and self-reported physical activity. Extrinsic motivation was not a significant predictor. (See Table 4). Girls in the group who reported consistent high intrinsic motivation engaged in an average of 5.9 minutes more of MVPA per day than girls who did not. This translates to about 40 minutes more per week of MVPA.

Discussion

Using a longitudinal sample of girls assessed across ages 9-13, this study examined predictors and consequences of girls' intrinsic and extrinsic motivation for physical activity. Ryan and Deci's (2000) Self-Determination Theory guided the selection of predictor variables and the hypotheses outlined in Figure 1. Results from this study provided partial support for Self-Determination Theory. As predicted by SDT, girls who reported high autonomy or high perceived competence at age 9 were more likely to report consistently high levels of intrinsic motivation across ages 9-13 and less likely to report consistently high levels of extrinsic motivation. Fulfillment of relatedness, the third basic psychological need identified by Ryan and Deci, was not, however, predictive of motivation. In addition, in accordance with SDT, girls who reported consistently high levels of intrinsic motivation across ages 9-13 engaged in an average of 5.6 more minutes of MVPA per day at age 13 than girls who did not report consistently high intrinsic motivation.

The finding that girls with higher levels of perceived autonomy were less likely to report consistently high levels of extrinsic motivation and more likely to report consistently high levels of intrinsic motivation for physical activity was congruent with previous research. Other studies have found perceptions of autonomy to be positively associated with intrinsic motivation amongst adults reporting on exercise behaviors (Edmunds, Ntoumanis, & Duda, 2006), secondary school students reporting on physical education classes (Standage, Duda, & Ntoumanis, 2003), and participants in a team-based intramural event (Wilson & Rodgers, 2004). In this study, motivation was domain-specific (physical activity) while autonomy was not domain-specific. This suggests that overall perceptions of autonomy may influence motivation in a variety of domains and therefore increasing an individual's general perceptions of autonomy in one context may result in increased intrinsic motivation in other areas.

Perceived competence was also related to extrinsic and intrinsic motivation in the directions predicted by SDT. Girls with higher levels of perceived athletic competence were less likely to report consistently high levels of extrinsic motivation and more likely to report persistent high levels of intrinsic motivation for physical activity. This is congruent with previous research that had found that perceived competence is positively associated with intrinsic motivation (Guay, Boggiano, & Vallerand, 2001; Markland, 1999; Paxton, Estabrooks, & Dzewaltowski, 2004). These findings provide support for the notion that individuals are likely to derive enjoyment from and be motivated to engage in activities in which they perceive themselves capable of succeeding.

Relatedness was not associated with either intrinsic or extrinsic motivation. While Ryan and Deci (2000) posit that fulfillment of the need for relatedness is a prerequisite for intrinsic motivation, they also acknowledge that the evidence for this link is much weaker than the evidence for the link between motivation and either autonomy or perceived competence. The pattern of findings from this study would appear to support this.

Congruent with Self-Determination Theory, intrinsic motivation was found to be a better predictor of behavior than was extrinsic motivation. That is, girls who reported consistently high intrinsic motivation across ages 9 to 13 years had higher levels of objectively-measured physical activity at age 13 than girls who did not report high intrinsic motivation. This contrasts with research by Edmunds and colleagues (2006) who found that for adult women, intrinsic motivation was not a significant predictor of exercise behaviors. It is congruent, however, with research that has found that persistence in physical activity behavior is predicted by intrinsic motivation in college age women (Pelletier, Fortier, Vallerand, & Briere, 2001) and adolescents (Sarrazin, Roberts, Cury, Biddle, & Famose, 2002). Inconsistencies in findings to date may reflect the age of the participants. Research in general supports the presence of effects for adolescents and college-aged participants, but not for adult women. This may reflect differences in priorities associated with different life stages and an ethic of care which results in women with families prioritizing the needs of their family members above their own enjoyment (Dupuis & Smale, 2000).

In contrast, no association was found between extrinsic (weight-related) motivation across ages 9 to 13 and girls' physical activity at age 13. Researchers have reported mixed results regarding the relationship between body-shape related motivation and participation in physical activity. (Segar, Spruijt-Metz, & Nolen-Hoeksema, 2006)reported that middle-aged women who reported body-shape motivations for physical activity were less likely to be physically active. Given the salience of physical appearance and weight for adolescent (Monsma, Malina, & Feltz, 2006), it seems unlikely that the lack of relationship found in this study is due to the girls in this study viewing weight control as unimportant. Rather, it seems reasonable to posit that extrinsic motivation is not sufficient to induce behavior change in this group even in pursuit of longer term outcomes they would value.

The strengths and weaknesses of this study should be considered while interpreting these results. The longitudinal design of the study allowed the examination of the relationship between predictors based on SDT and levels of motivation across time. In addition, the use of an objective measure of physical activity allowed the relationship between intrinsic and extrinsic motivation and physical activity to be examined without concerns regarding socially desirable responding among girls who reported that they were motivated to be physically active but did not actually engage in correspondingly high levels of physical activity. While the study design and measures used were strengths of this study, there were also several limitations. Participants in the study were Caucasian girls residing in central Pennsylvania. Therefore, results may not generalize across geographic areas or ethnicities. In addition, objective measures of physical activity were not available prior to age 13 so it was not possible to examine whether or not higher levels of physical activity were predictive of intrinsic motivation rather than the reverse. Future research should address these weaknesses by examining the models tested in this study in ethnically and geographically diverse samples. In addition, repeated objective measures of physical activity would allow for changes in physical activity based on motivations to be examined.

In summary, the findings from this study generally supported the propositions of Self Determination Theory. Girls who reported higher levels of perceived autonomy and athletic competence at age 9 were more likely to report persistently high intrinsic (enjoyment-related) motivation across ages 9-13 and less likely to report persistently high extrinsic (weight-related) motivation. In addition, girls who reported persistent high intrinsic motivation engaged in significantly more physical activity than girls who did not, while extrinsic motivation was not related to physical activity. The finding of a relationship between consistently high levels of intrinsic motivation and higher levels of physical activity highlights the importance of facilitating intrinsic motivation when promoting health behaviors. Environments that support self-determined, enjoyable experiences, and promote the development of skills and a sense of competence are more likely to produce and maintain healthy behaviors than are environments that encourage behaviors for external reasons (Ryan & Deci, 2000). These features are likely to be found in leisure settings characterized by relative autonomy and intrinsic motivation. Based on findings from this study, programs and interventions designed to promote physical activity should focus on providing participants with opportunities for choice, skill development, and enjoyable experiences.

References

Aaron, D. J., Storti, K. L., Robertson, R. J., Kriska, A. M., & LaPorte, R. E. (2002). Longitudinal study of the number and choice of leisure time physical activities from mid to late adolescence: implications for school curricula and community recreation programs. *Archives of Pediatric and Adolescent Medicine, 156*(11), 1075-1080.

Alexandris, K., Kouthouris, C., & Girgolas, G. (2007). Investigating the relationships among motivation, negotiation, and alpine skiing participation. *Journal of Leisure Research,* 39, 648-667.

Balwin, C. K., & Caldwell, L. L. (2003). Development of a free time motivation scale for adolescents. *Journal of Leisure Research, 35*(2), 129-151.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

Cash, T. F., Novy, P. L., & Grant, J. R. (1994). Why do women exercise? Factor analysis and further validation of the Reasons for Exercise Inventory. *Perceptual & Motor Skills, 78*(2), 539-544.

Caspersen, C. J., Pereira, M. A., & Curran, K. M. (2000). Changes in physical activity patterns in the United States, by sex and cross-sectional age. *Medicine and Science in Sports and Exercise, 32*(9), 1601-1609.

Centers for Disease Control and Prevention. (2006). Youth risk behavior surveillance--United States, 2005. *Morbidity and mortality weekly report. CDC surveillance summaries, 55*(5), 1-108.

Csikszentmihalyi, M. (1991). *Flow: The psychology of optimal experience*. New York: Harper Collins.

Csikszentmihalyi, M., & Kleiber, D. A. (1991). Leisure and self-actualization. In Driver O. L., Brown P. J., and Peterson G. L., (eds.), *Benefits of Leisure*. pp. 91–102. Venture: State College, PA.

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227-268.

Edmunds, J., Ntoumanis, N., & Duda, J. L. (2006). A test of self-determination theory in the exercise domain. *Journal of Applied Social Psychology, 36*(9), 2240-2265.

Ellis, K. J., Shypailo, R. J., Pratt, J. A., & Pond, W. G. (1994). Accuracy of dual-energy x-ray absorptiometry for body-composition measurements in children. *American Journal of Clinical Nutrition, 60,* 660-665.

Freedson, P. S., Pober, D., & Janz, K. F. (2005). Calibration of accelerometer output for children. *Medicine and Science in Sports and Exercise, S37*(11), S523-530.

Gavazzi, S. M. (1993). The relation between family differentiation levels in families with adolescents and the severity of presenting problems. *Family Relations, 42*(4), 463-468.

Gillison, F. B., Standage, M., & Skevington, S. M. (2006). Relationships among adolescents' weight perceptions, exercise goals, exercise motivation, quality of life and leisure-time exercise behaviour: a self-determination theory approach. *Health Education Research, 21*(6), 836-847.

Goodale, T. L. & Godbey, G. C. (1988). The evolution of leisure: Historical and philosophical perspectives. State College, PA: Venture Publishing.

Goodin, R. E., Rice, J. M., Bittman, M., & Saunders, P. (2005). The time pressure illusion: Discretionary time vs. free time. *Social Indicators Research, 73,* 43–70.

Goran, M. I., Driscoll, P., Johnson, R., Nagy, T. R., & Hunter, G. (1996). Cross-calibration of body-composition techniques against dual-energy X-ray absorptiometry in young children. *American Journal of Clinical Nutrition, 63*, 299-305.

Grotevant, H. (1998). Adolescent Development in Family Contexts. In N. Eisenberg (Ed.), *Handbook of Child Psychology* (Fifth ed., Vol. Three: Social, Emotional, and Personality Development). Hoboken: Jeffrey W. Brown.

Guay, F., Boggiano, A. K., & Vallerand, R. J. (2001). Autonomy support, intrinsic motivation, and perceived competence: Conceptual and empirical linkages. *Personality and Social Psychology Bulletin, 27*(6), 643-650.

Hagger, M. S., Chatzisarantis, N. L. D., & Harris, J. (2006). The process by which relative autonomous motivation affects intentional behavior: Comparing effects across dieting and exercise behaviors. *Motivation and Emotion, 30*(4), 307-321.

Harter, S. (1985). *Manual for the self-perception profile for children*. Denver, CO: University of Denver .

Jago, R., Anderson, C. B., Baranowski, T., & Watson, K. (2005). Adolescent patterns of physical activity differences by gender, day, and time of day. *American Journal of Preventive Medicine, 28*(5), 447-452.

Kerr, M., & Stattin, H. (2000). What parents know, how they know it, and several forms of adolescent adjustment: Further support for a reinterpretation of monitoring. *Developmental Psychology, 36*(3), 366-380.

Kimm, S. Y., Glynn, N. W., Kriska, A. M., Barton, B. A., Kronsberg, S. S., Daniels, S. R., et al. (2002). Decline in physical activity in black girls and white girls during adolescence. *The New England Journal of Medicine, 347*(10), 709-715.

Lukaski, H. C. (1993). Soft tissue composition and bone mineral status: Evaluation by dual-energy X-ray absorptiometry. *The Journal of Nutrition, 123*(2), 438-443.

Markland, D. (1999). Self-determination moderates the effects of perceived competence on intrinsic motivation in an exercise setting. *Journal of Sport & Exercise Psychology, 21*(4), 351.

Masse, L. C., Fuemmeler, B. F., Anderson, C. B., Matthews, C. E., Trost, S. G., Catellier, D. J., et al. (2005). Accelerometer data reduction: a comparison of four reduction algorithms on select outcome variables. *Medicine and Science in Sports and Exercise, 37*(11 Suppl), S544-554.

Mazess, R. B., Barden, H. S., Bisek, J. P., & Hanson, J. (1990). Dual-energy x-ray absorptiometry for total-body and regional bone-mineral and soft-tissue composition. *American Journal of Clinical Nutrition, 51*(6), 1106-1112.

Monsma, V. E., Malina, M. R., & Feltz, L. D. (2006). Puberty and physical self-perceptions of competitive female figure skaters: An interdisciplinary approach. *Research Quarterly for Exercise and Sport, 77*(2), 158.

National Center for Health Statistics. (2005). *Health, United States, 2005 With Chartbook on Trends in the Health of Americans.* . Hyattsville, Maryland: National Center for Health Statistics.

Nilsson, A., Ekelund, U., Yngve, A., & Sjostrom, M. (2002). Assessing physical activity among children with accelerometers using different time sampling intervals and placements. *Pediatric Exercise Science, 14*, 87-96.

Ntoumanis, N. (2005). A prospective study of participation in optional school physical education using a self-determination theory framework. *Journal of Educational Psychology, 97*(3), 444-453.

Paxton, R. J., Estabrooks, P. A., & Dzewaltowski, D. (2004). Attraction to physical activity mediates the relationship between perceived competence and physical activity in youth. *Research Quarterly for Exercise and Sport, 75*(1), 107-111.

Pelletier, L. G., Fortier, M. S., Vallerand, R. J., & Briere, N. M. (2001). Associations among perceived autonomy support, forms of self-regulation, and persistence: A prospective study. *Motivation and Emotion, 25*(4), 279-306.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78.

Ryan, R. M., & Deci, E. L. (2006). Self-regulation and the problem of human autonomy: Does psychology need choice, self-determination, and will? *Journal of Personality, 74*(6), 1557-1586.

Sharp, E. H., Caldwell, L. L., Graham, J. W., & Ridenour T. A. (2006). Individual Motivation and Parental Influence on Adolescents' Experiences of Interest in Free Time: A Longitudinal Examination. *Journal of Youth and Adolescence,* 35(3), 359–372.

Standage, M., Duda, J. L., & Ntoumanis, N. (2003). A model of contextual motivation in physical education: Using constructs from self-determination and achievement goal theories to predict physical activity intentions. *Journal of Educational Psychology*, *95*(1), 97-110.

Stebbins, R. A. (2005). Choice and Experiential Definitions of Leisure. *Leisure Sciences, 27*, 349 – 352.

Strelan, P., Mehaffey, S. J., & Tiggemann, M. (2003). Brief report: Self-objectification and esteem in young women: The mediating role of reasons for exercise. *Sex Roles*, *48*(1), 89-95.

Trost, S. G., Pate, R. R., Sallis, J. F., Freedson, P. S., Taylor, W. C., Dowda, M., et al. (2002). Age and gender differences in objectively measured physical activity in youth. *Medicine and Science in Sports and Exercise, 34*, 350-355.

Vallerand, R. J., Fortier, M. S., & Guay, F. (1997). Self-determination and persistence in a real-life setting: toward a motivational model of high school dropout. *Journal of Personality and Social Psychology, 72*(5), 1161-1176.

Wilson, P. M., & Rodgers, W. M. (2004). The relationship between perceived autonomy support, exercise regulations and behavioral intentions in women. *Psychology of Sport and Exercise, 5*(3), 229-242.

Zick, C. D. (2007). *Over-scheduled or at loose ends? The shifting balance of adolescent time use*. Paper presented at the Annual Meeting of the Population Association of America. New York City, March 29-31.

Table 3.1: Means and Standard Deviations of Variables

Measures	Girls' Age Age 9	 Age 11	 Age 13
Perceived Autonomy	2.95 (.78)		
Perceived Athletic Competence	2.878 (.67)		
Perceived Relatedness	4.40 (.49)		
Percent Body Fat	27.23 (7.18)		
Extrinsic Motivation	1.58 (.73)	1.60 (.71)	1.77 (.78)
Intrinsic Motivation	3.77 (.61)	3.78 (.57)	3.68 (.66)
Minutes of MVPA per day			35.82 (14.90)

Table 3.2: Logistic Regression Predicting High Persistent Extrinsic Motivation

	Odds Ratio	95% Confidence Interval	Sig.
Perceived Autonomy	.355	.169 - .744	**.006**
Perceived Athletic Competence	.352	.142- .871	**.024**
Perceived Relatedness	.728	.206- 2.572	.622
Percent Body Fat	1.142	1.052- 1.239	**.002**
SES	1.002	.631- 1.590	.994
Constant	5.064		.569

Table 3.3: Logistic Regression Predicting High Persistent Intrinsic Motivation

	Odds Ratio	95% Confidence Interval	Sig.
Perceived Autonomy	1.937	1.116 - 3.362	**.019**
Perceived Athletic Competence	2.011	1.050 - 3.848	**.035**
Perceived Relatedness	.835	.344 - 2.030	.691
Percent Body Fat	.987	.933 - 1.045	.659
Socioeconomic Status	.769	.563 - 1.051	.100
Constant	2.608		.679

Table 3.4: Regression predicting minutes of MVPA per day

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	43.998	5.792		7.596	.000
Extrinsic Motivation[1]	4.259	3.716	.110	1.146	.254
Intrinsic Motivation[1]	5.586	2.746	.182	2.034	**.044**
Percent Body Fat	-.448	.202	-.216	-2.224	**.028**
SES	.484	1.016	.044	.477	.634

1. Both Extrinsic and Intrinsic motivation were entered as dichotomous variables.

Figure 3.1: Conceptual Model of Hypotheses

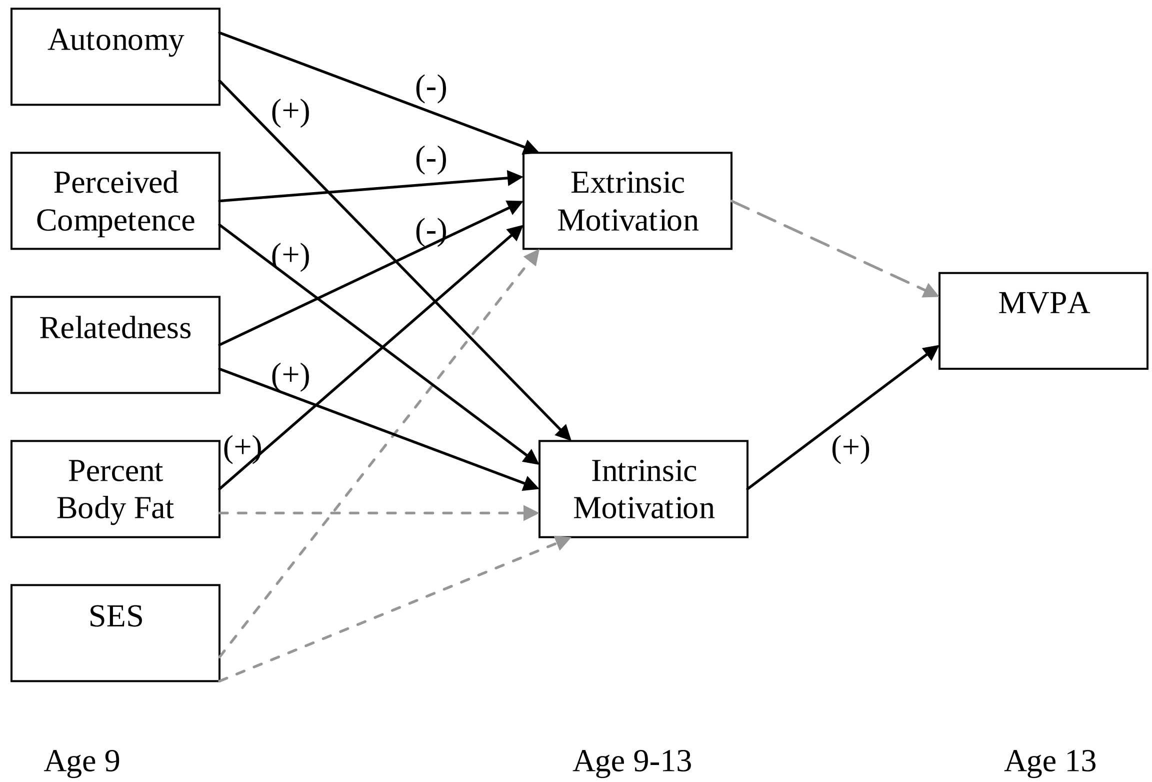
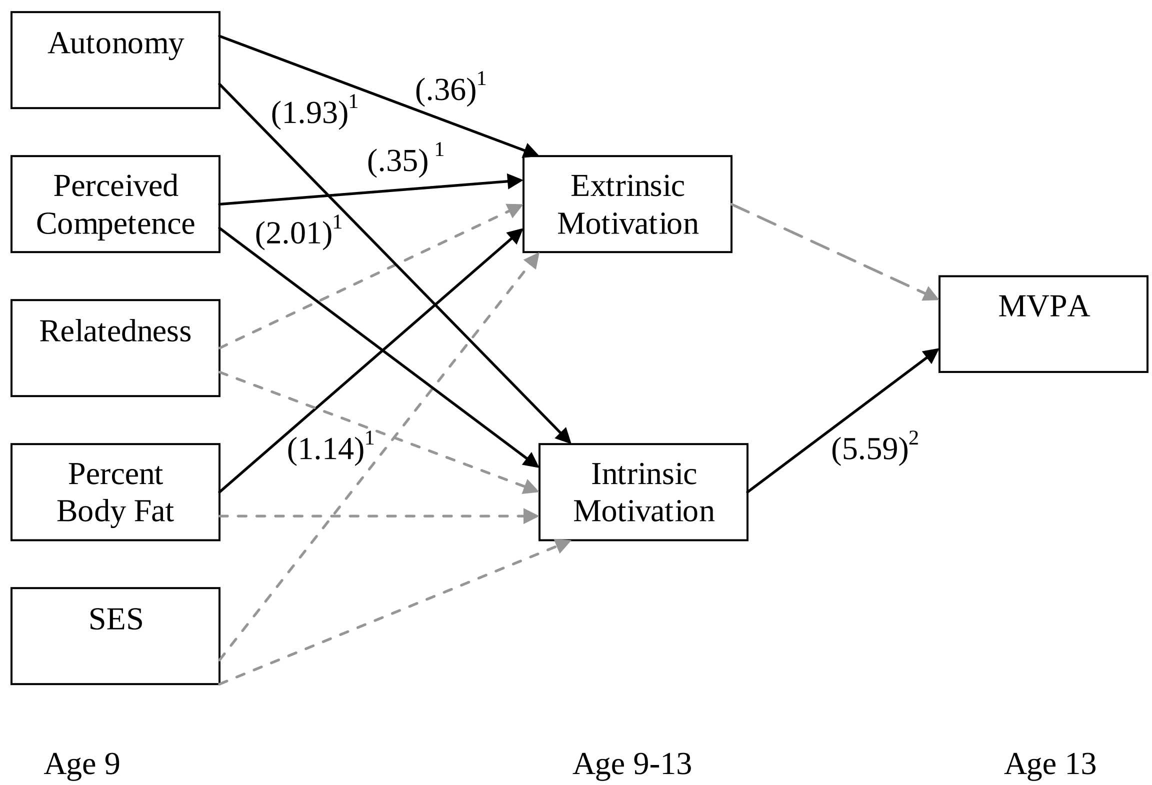


Figure 3.2: Model of Results



[1] Odds ratio from logistic regression
[2] Unstandardized beta weight from OLS regression

REFERENCES

Baldwin, C. K., & Caldwell, L. L. (2003). Development of a free time motivation scale for adolescents. *Journal of Leisure Research, 35*(2), 129-151.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

Csikszentmihalyi, M. (1991). *Flow: The psychology of optimal experience*. New York: Harper Collins.

Darling, N., Caldwell, L. L., & Smith, R. (2005). Participation in school-based extracurricular activities and adolescent adjustment. *Journal of Leisure Research, 37*(1), 51-77.

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227-268.

Dupuis, S. L., & Smale, B. (2000). Bittersweet journeys: Meanings of leisure in the institution-based caregiving context. *Journal of Leisure Research, 32*(3), 303–340.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Reviews in Psychology, 53*(1), 109-132.

Edmunds, J., Ntoumanis, N., & Duda, J. L. (2006). A test of self-determination theory in the exercise domain. *Journal of Applied Social Psychology, 36*(9), 2240-2265.

Ellis, K. J., Shypailo, R. J., Pratt, J. A., & Pond, W. G. (1994). Accuracy of dual-energy x-ray absorptiometry for body-composition measurements in children. *American Journal of Clinical Nutrition, 60*, 660-665.

Ferrer-Caja, E., & Weiss, M. R. (2000). Predictors of intrinsic motivation among adolescent students in physical education. *Research Quarterly for Exercise and Sport, 71*(3), 267-279.

Freedson, P., Pober, D., & Janz, K. F. (2005). Calibration of accelerometer output for children. *Medicine and Science in Sports and Exercise, 37*(11 Suppl), S523-S530.

Gavazzi, S. M. (1993). The relation between family differentiation levels in families with adolescents and the severity of presenting problems. *Family Relations, 42*(4), 463-468.

Gillison, F. B., Standage, M., & Skevington, S. M. (2006). Relationships among adolescents' weight perceptions, exercise goals, exercise motivation, quality of life and leisure-time exercise behaviour: a self-determination theory approach. *Health Education Research, 21*(6), 836-847.

Godbey, G. C., Caldwell, L. L., Floyd, M., & Payne, L. L. (2005). Contributions of leisure studies and recreation and park management research to the active living agenda. *American Journal of Preventive Medicine, 28*(2 Suppl 2), 150-158.

Goran, M. I., Driscoll, P., Johnson, R., Nagy, T. R., & Hunter, G. (1996). Cross-calibration of body-composition techniques against dual-energy X-ray absorptiometry in young children. *American Journal of Clinical Nutrition, 63*, 299-305.

Grotevant, H. (1998). Adolescent development in family contexts. In N. Eisenberg (Ed.), *Handbook of Child Psychology* (Fifth ed., Vol. Three: Social, Emotional, and Personality Development): Jeffrey W. Brown.

Guay, F., Boggiano, A. K., & Vallerand, R. J. (2001). Autonomy support, intrinsic motivation, and perceived competence: Conceptual and empirical linkages. *Personality and Social Psychology Bulletin, 27*(6), 643-650.

Harter, S. (1985). *Manual for the self-perception profile for children*. Denver, CO: University of Denver

Haverly, K., & Davison, K. K. (2005). Personal fulfillment motivates adolescents to be physically active. *Archives of Pediatric Adolescent Medicine*, *159*(12), 1115-1120.

Kerr, M., & Stattin, H. (2000). What parents know, how they know it, and several forms of adolescent adjustment: Further support for a reinterpretation of monitoring. *Developmental Psychology, 36*(3), 366-380.

Larson, R., & Seepersad, S. (2003). Adolescents' leisure time in the United States: Partying, sports, and the American experiment. *New Directions in Child and Adolescent Development, 99,* 53-64.

Larson, R. W. (2000). Toward a psychology of positive youth development. *American Psychologist, 55*(1), 170-183.

Lukaski, H. C. (1993). Soft tissue composition and bone mineral status: Evaluation by dual-energy X-ray absorptiometry. *The Journal of Nutrition, 123*(2), 438-443.

Markland, D. (1999). Self-determination moderates the effects of perceived competence on intrinsic motivation in an exercise setting. *Journal of Sport & Exercise Psychology, 21*(4), 351.

Mâsse, L. C., Fuemmeler, B. F., Anderson, C. B., Matthews, C. E., Trost, S. G., Catellier, D. J., et al. (2005). Accelerometer data reduction: A comparison of four reduction algorithms on select outcome variables. *Medicine and Science in Sports and Exercise, 37*(11 Suppl), S544-S554.

Mazess, R. B., Barden, H. S., Bisek, J. P., & Hanson, J. (1990). Dual-energy x-ray absorptiometry for total-body and regional bone-mineral and soft-tissue composition. *American Journal of Clinical Nutrition, 51*(6), 1106-1112.

Monsma, V. E., Malina, M. R., & Feltz, L. D. (2006). Puberty and physical self-perceptions of competitive female figure skaters: An interdisciplinary approach. *Research Quarterly for Exercise and Sport, 77*(2), 158.

Nilsson, A., Ekelund, U., Yngve, A., & Sjostrom, M. (2002). Assessing physical activity among children with accelerometers using different time sampling intervals and placements. *Pediatric Exercise Science, 14*, 87-96.

Ntoumanis, N. (2001). Empirical links between achievement goal theory and self-determination theory in sport. *Journal of Sports Sciences, 19*(6), 397-409.

Ntoumanis, N. (2005). A prospective study of participation in optional school physical education using a self-determination theory framework. *Journal of Educational Psychology, 97*(3), 444-453.

Ntoumanis, N., & Biddle, S. J. H. (1999). A review of motivational climate in physical activity. *Journal of Sports Sciences, 17*(8), 643-665.

Paxton, R. J., Estabrooks, P. A., & Dzewaltowski, D. (2004). Attraction to physical activity mediates the relationship between perceived competence and physical activity in youth. *Research Quarterly for Exercise and Sport, 75*(1), 107-111.

Pelletier, L. G., Fortier, M. S., Vallerand, R. J., & Briere, N. M. (2001). Associations among perceived autonomy support, forms of self-regulation, and persistence: A prospective study. *Motivation and Emotion, 25*(4), 279-306.

Prusak, K. A., Treasure, D. C., Darst, P. W., & Pangrazi, R. P. (2004). The effects of choice on the motivation of adolescent girls in physical education. *Journal of Teaching in Physical Education, 23*(1), 11.

Ross, J. G., Dotson, C. O., Gilbert, G. G., & Katz, S. J. (1985). After physical education. Physical activity outside of school physical education programs. *Journal of Physical Education, Recreation, and Dance, 56*(1), 77-81.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78.

Sarrazin, P., Roberts, G., Cury, F., Biddle, S., & Famose, J. P. (2002). Exerted effort and performance in climbing among boys: The influence of achievement goals, perceived ability, and task difficulty. *Research Quarterly for Exercise and Sport, 73*(4), 425-436.

Segar, M., Spruijt-Metz, D., & Nolen-Hoeksema, S. (2006). Go figure? Body-shape motives are associated with decreased physical activity participation among midlife women. *Sex Roles, 54*(3-4), 175-187.

Sharp, E. H., Caldwell, L. L., Graham, J. W., & Ridenour, T. A. (2006). Individual motivation and parental influence on adolescents' experiences of interest in free time: A longitudinal examination. *Journal of Youth and Adolescence, 35*(3), 340.

Standage, M., Duda, J. L., & Ntoumanis, N. (2003). A model of contextual motivation in physical education: Using constructs from self-determination and achievement goal theories to predict physical activity intentions. *Journal of Educational Psychology, 95*(1), 97-110.

Troiano, R. P., Berrigan, D., Dodd, K. W., Masse, L. C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine & Science in Sports & Exercise, 40*(1), 181-188.

Trost, S. G., McIver, K. L., & Pate, R. R. (2005). Conducting accelerometer-based activity assessments in field-based research. *Medicine and Science in Sports and Exercise, 37*(11 Suppl), S531-S543.

Trost, S. G., Pate, R. R., Sallis, J. F., Freedson, P. S., Taylor, W. C., Dowda, M., et al. (2002). Age and gender differences in objectively measured physical activity in youth. *Medicine and Science in Sports and Exercise, 34*(2), 350-355.

Trost, S. G., Ward, D. S., Moorehead, S. M., Watson, P. D., Riner, W., & Burke, J. R. (1998). Validity of the computer science and applications (CSA) activity monitor in children. *Medicine and Science in Sports and Exercise, 30*(4), 629-633.

Vansteenkiste, M., Simons, J., Soenens, B., & Lens, W. (2004). How to become a persevering exerciser? Providing a clear, future intrinsic goal in an autonomy-supportive way. *Journal of Sport & Exercise Psychology, 26*(2), 232-249.

Vierling, K. K., Standage, M., & Treasure, D. C. (2007). Predicting attitudes and physical activity in an 'at-risk' minority youth sample: A test of self-determination theory. *Psychology of Sport and Exercise, 8*, 795-817.

Wilson, P. M., & Rodgers, W. M. (2004). The relationship between perceived autonomy support, exercise regulations and behavioral intentions in women. *Psychology of Sport and Exercise, 5*(3), 229-242.

Zick, C. D. (2007). *Over-scheduled or at loose ends? The shifting balance of adolescent time use*. Paper presented at the Annual Meeting of the Population Association of America. New York City, March 29-31

Orientation to Chapter 4

This is a manuscript that will be submitted to *International Journal of Obesity Research* for publication. The purpose of this study was to examine predictors and outcomes of perceived athletic competence and change in perceived athletic competence. Sport participation, body fat percentage, and breast development were examined as potential predictors, while physical activity was the outcome of interest.

H1: Age 9 participation in aesthetic sports (positive), participation in non-aesthetic sports (positive), body fatness (negative), and breast development (negative) will be predictors of age 11 level and age 11-13 change in perceived athletic competence in the direction indicated beside them.

H2: Age 11 level of perceived competence and change in perceived athletic competence between ages 11 and 13 will be positive predictors of age 13 MVPA.

CHAPTER 4

I KNOW I CAN: A LONGITUDINAL EXAMINATION OF PRECURSORS AND OUTCOMES OF PERCEIVED ATHLETIC COMPETENCE AMONG ADOLESCENT GIRLS

Abstract

PURPOSE: To examine predictors and outcomes of perceived athletic competence and change in perceived athletic competence in a longitudinal sample of adolescent girls. Sport participation, body fat percentage, and breast development were examined as potential predictors, while physical activity was the outcome of interest. METHODS: A sample of 168 adolescent girls was assessed at ages 9, 11, and 13. Perceived athletic competence was measured at all ages. Sport participation, body fat percentage, and breast development were measured at age 9. Accelerometers were used to measure girls' moderate-to-vigorous physical activity (MVPA) at age 13. RESULTS: Lower percentage body fat and higher sport participation at age 9 predicted higher perceived athletic competence at age 11, while more advanced breast development at age 9 was associated with greater declines in perceived athletic competence between ages 11 and 13. Both perceived athletic competence at age 11 and the change in perceived athletic competence between ages 11 and 13 were significant positive predictors of age 13 MVPA. Results were independent of age 9 socioeconomic status and self-reported physical activity. CONCLUSION: Perceived athletic competence is a suitable target for intervention efforts designed to increase adolescent girls' physical activity. Particular attention should be focused on girls who are overweight and who are experiencing puberty as findings indicate that girls with higher body fat are at increased risk of low levels of perceived athletic competence and girls with higher levels of breast development are likely to experience steeper declines in perceived athletic competence.

Perceived athletic competence is positively associated with participation in physical activity (Sollerhed, Apitzsch, Rastam, & Ejlertsson, 2008; Trost et al., 1997; Welk & Schaben, 2004), which may be a result of the links between perceived competence, intrinsic motivation, and persistence in the face of challenges (Harter, 1985). The relationship between perceived athletic competence and physical activity may be of particular importance in adolescent girls as physical activity rates are low in this population (CDCP, 2006; Jago, Anderson, Baranowski, & Watson, 2005) and display a marked decline with age (Aaron, Storti, Robertson, Kriska, & LaPorte, 2002; Caspersen, Pereira, & Curran, 2000; CDCP, 2006; Kimm et al., 2002; National Center for Health Statistics, 2005). The association between perceived athletic competence and physical activity has not, however, been extensively studied in adolescent girls (Biddle, Whitehead, O'Donovan, & Nevill, 2005). Furthermore, little is known about the predictors of girls' perceived competence. The studies that have been conducted have generally relied on cross-sectional data and have used self-reported physical activity, which limits their application. A detailed examination of predictors and outcomes of perceived athletic competence in adolescent girls may help to inform intervention efforts with this vulnerable population. Therefore, using a longitudinal sample of adolescent girls, the purpose of this paper is to examine precursors of girls' perceived athletic competence and change in perceived competence and links between perceived competence and girls' objectively measured physical activity.

Perceived competence and adolescent girls' physical activity

There is considerable evidence that boys are more physically active than girls (Jago, Anderson, Baranowski, & Watson, 2005; Trost et al., 2002). This may be partially explained by the higher levels of perceived athletic competence reported by boys (Crocker, Eklund, &

Kowalski, 2000; Marsh, 1998; Shapka & Keating, 2005). Therefore, enhancing adolescent girls' perceived athletic competence may result in concomitant increases in physical activity and reduce gender-related physical activity disparities.

Relatively little research, however, focused on predictors and outcomes of girls' perceived athletic competence. In a review of the literature, Biddle and colleagues (2005) found only 5 studies that reported on the relationship between perceived competence and physical activity in adolescent girls and stated that while the evidence indicated a link between the two, more research was needed. Since this review, a few additional articles have been published that examined this relationship. The majority of these studies, however, examined physical activity as a predictor of physical self-concept rather than perceived athletic competence as a predictor of physical activity.

Furthermore, little is known about outcomes of changes in perceived athletic competence during adolescence. Apparently inconsistent patterns of change in perceived athletic competence have been reported in the literature. Some authors have indicated that self perceptions of physical competence decline with age across late childhood and early adolescence (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002), while others have found that perceived athletic competence is relatively stable across time (Kowalski et al., 2003; Shapka & Keating, 2005). Others have suggested that perceived athletic competence declines in early adolescence and then increases somewhat in later adolescence (Marsh, 1998). The stability observed in some studies may have been a result of the interval used (one year) rather than evidence of a lack of change (Kowalski et al., 2003). Supporting this notion, studies which showed a decline had longer periods of measurement than those that did not show a change. Although apparently contradictory, these studies are consistent with a pattern in which perceived athletic competence declines in early adolescence, levels off, and then increases in late adolescence. Although research generally suggests that higher perceived athletic competence is associated with higher levels of physical activity and that perceived competence declines during early adolescence among girls, few studies have assessed the relationship between changes in perceived athletic competence and girls' objectively measured physical activity.

Predictors of adolescent girls' perceived athletic competence

In addition to patterns of perceived athletic competence and their associations with physical activity, predictors of perceived athletic competence are of interest as these may identify opportunities for intervention. Perceptions of athletic competence develop across time as a result of experiences and interpretations of those experiences (Monsma, Malina, & Feltz, 2006). Researchers have identified a variety of contextual, psychological, and biological factors that are associated with perceived athletic competence. Previous sport experience has been identified as a contextual contributor to perceived athletic competence (Bandura, 1997; Papaioannou, Bebetsos, Theodorakis, Christodoulidis, & Kouli, 2006) while biological factors identified in the literature include body fatness and pubertal maturation, which are both negatively related to athletic competence (Dunton, Jamner, & Cooper, 2003; Monsma, Malina, & Feltz, 2006).

Bandura (1997) identifies enactive attainment (having completed a task in the past) as a source of increased competency beliefs. This suggests that girls who have previous experience in sport and physical activity will rate their abilities higher than those who have not had previous experience. Researchers have suggested, however, that the relationship between sport participation and self-perception may vary depending on the type of sport. One distinction that has been made in the literature is between aesthetic sports where leanness and appearance are emphasized and outcomes are often determined by judges rather than by time or points scores and non-aesthetic sports where outcomes are independent of appearance. Although female athletes in general report more positive perceptions of their physical appearance, athletic competence and body image than non-athletes (Miller & Levy, 1996), participation in aesthetic sports is associated with higher weight concerns, higher risk of eating disorders, and lower body satisfaction compared with non-aesthetic sports (Davison, Earnest, & Birch, 2002; Ravaldi et al., 2003; Torstveit & Sundgot-Borgen, 2005). Monsma and colleagues (2006) indicated that participation in aesthetic sports may contribute less to perceived athletic competence compared to participation in non-aesthetic sports. While this research suggests that aesthetic and non-aesthetic sports differ in their relationship to physical-concept, this has not been examined in relation to perceived athletic competence.

In addition to contextual factors such as type of sport participation, research indicates that biological factors such as puberty and body fatness are negatively associated with perceived athletic competence. Consequently, researchers have suggested that the decline in perceived athletic competence across time observed in some studies may actually be the result of puberty rather than age per se (Monsma, Malina, & Feltz, 2006). Physical changes associated with puberty, such as increases in body fatness, may result directly in poorer performance or in discomfort that leads to poorer performance (Malina, Bouchard, & Bar-Or, 2004). These decreases in objective performance often lead to a decrease in perceived athletic competence (Craft et al, 2003; Monsma, Malina, & Feltz, 2006). Alternatively, psychological changes associated with puberty such as increases in depression (Motl, Birnbaum, Kubik, & Dishman, 2004) and decreases in body satisfaction (Graber, Brooks-Gunn, & Warren, 1999) may be associated with decreases in girls' perceived competence.

Goals of the study

This study extends previous research in four ways; 1) by including precursors and outcomes of perceived athletic competence in a single model 2) by examining both level of and change in perceived athletic competence, 3) by using an objective measure of physical activity, and 4) by employing a longitudinal design. In doing so, two specific objectives are addressed. First, this study examines perceived athletic competence at age 11 and change in perceived athletic competence across ages 11 to 13 as predictors of girls' objectively measured physical activity at age 13. Based on previous research, it was hypothesized that age 11 perceived competence and change in perceived competence between ages 11 and 13 are positive predictors of age 13 physical activity. Second, this study examines sport participation (including aesthetic and non-aesthetic sport participation), pubertal development, and body fat at age 9 as predictors of level (age 11) and change (age 11 to 13) in perceived athletic competence. Based on perceived athletic competence, it is predicted that aesthetic and non-aesthetic sport participation have a positive relationship with level of and change in perceived athletic competence, with non-aesthetic sport being a stronger predictor than aesthetic sport. In addition, it was hypothesized that age 9 percent body fat and pubertal development are negative predictors of level of and change in perceived athletic competence. We conceptualized the relationships outlined as a mediation model in which level of and change in perceived competence mediate the relationships between the age 9 variables and age 13 MVPA (See Figure 1).

Methods

Participants

Participants were part of a longitudinal study examining girls' nutrition, dieting, physical activity, and health. Data for this study were collected when the girls' were ages 9 (n=183), 11(n=177), and 13 (n=168). Participants visited the university lab at each time point where body fat and breast development measures and questionnaire data were obtained. In addition, they wore accelerometers for one week. Girls who dropped out of the study between ages 9 and 13 did not differ from those who remained in the study on age 9 measures of body fatness, parental education, perceived athletic competence, breast development, or self-reported physical activity. Approval for research involving human participants was obtained from the Institutional Review Board at the Pennsylvania State University. Written parental consent and participant assent was obtained for all procedures.

Measures

Perceived athletic competence was measured at ages 9, 11, and 13. Measures of sport participation, body fat percentage, breast development, socioeconomic status, and self-report physical activity were obtained at age 9. Accelerometers were used to measure age 13 physical activity.

Perceived athletic competence. Perceived athletic competence was measured using the athletic competence subscale of the Self – Perception Profile for Children (Harter, 1985) at age 9 and the athletic competence subscale of an amended version of the Self-Perception Profile for Adolescents (Harter, 1988) at ages 11 and 13. The 6 items comprising the athletic competence subscale were analogous in content in both versions. In the children's version, the respondent is presented with descriptions of two children (eg. Some kids do very *well* at all kinds of sports vs, Other kids *don't* feel that they are very good when it comes to sports) and asked to indicate which is most like her and whether the child she selected is 'a little like her' or 'a lot like her'. In the amended adolescent version, the respondent is presented with a statement (eg. I do very well at all kinds of sports) and asked to indicate on a scale of 1 to 4 how strongly they agree with it.

The change to the single statement form of the question was the only difference between the amended and original adolescent version. Research has demonstrated superior psychometric properties in the amended version (Wichstrom, 1995). Higher scores on this subscale indicate higher perceived competence. In this sample, the internal consistency co-efficients were α=.80 at age 9, α=.84 at age 11 and α=.86 at age 13 indicating acceptable internal reliability.

Sport participation. An activity checklist was developed for this study. Girls were presented with a list of 21 sports and activities (eg. dance) and asked to indicate if they participate in the sport/activity in an organized form (eg. on a team or through extracurricular lessons). These activities were divided into aesthetic sports (outcomes are influenced by appearance) and non-aesthetic sports (outcomes are independent of appearance). Sports or activities that were classified as aesthetic sports included gymnastics, dance, baton-twirling, aerobics, ice skating and cheerleading. Those classified as non-aesthetic sports included volleyball, basketball, soccer, hockey, tennis, and softball. Dichotomous variables were created for aesthetic and non-aesthetic sports indicating whether or not the girl participates in that type of organized sport or activity.

Percent Body Fat. Dual-energy X-Ray absorptiometry (DXA) was used to measure girls' percent body fat at age 9. Whole body scans were done using the Hologic QDR 4500W (S/N 47261) in the array scan mode and analyzed using whole body software, QDR4500 Whole Body Analysis. DXA has received widespread use and is the preferred method of assessing body composition among children, because it provides an accurate, reliable, and non-invasive means of quantifying bone mineral content and body mass content, including fat and lean mass, while minimizing radiation exposure during measurement (Ellis, Shypailo, Pratt, & Pond, 1994; Goran, Driscoll, Johnson, Nagy, & Hunter, 1996; Lukaski, 1993; Mazess, Barden, Bisek, & Hanson, 1990).

Breast Development. Girls' breast development was assessed at age 9 using Tanner's criteria for pubertal breast stages (Marshall & Tanner, 1969). Stages range from 1 (no development) to 5 (mature development). Visual inspection of each breast was made unobtrusively by a trained nurse and a nurse's assistant while using a stethoscope to check heart rate. In cases where ratings of the two breasts were not equal, the lower stage was used because the girl had not fully attained the higher stage.

SES. Parents reported their education levels and family income. A composite measure of family SES status created using principal components analysis of mother's education, father's education, and family income.

Self-reported physical activity. The Children's Physical Activity scale (CPA) was used to measure girls' self-reported physical activity at age 9. In a self-administered survey, girls responded to 15 questions such as "I participate in sports almost every day" using a 4-point scale ranging from 1=completely false to 4=completely true. Scores on the fifteen items were averaged to create a score ranging from one (low activity) to four (high activity). In previous studies, scores on the CPA have been correlated in the expected direction with one-mile run/walk time ($r = -.43$, $p < 0001$), body fat percentage ($r = -.41$, $p <.0001$), and BMI ($r = - .32$, $p <.0001$) (L. A. Tucker, Seljaas, & Hager, 1997). The internal consistency co-efficient for the CPA in this study was $\alpha=.67$.

Accelerometer measured physical activity. Objective assessments of physical activity were obtained using the ActiGraph 7164 accelerometer (Shalimar, FL). For the current study, a 30 s epoch was used. The Actigraph 7164 has been shown to be a valid and reliable tool for assessing physical activity in children and adolescents (S. G. Trost et al., 1998). After receiving detailed instructions regarding the care and use of the accelerometers, girls were instructed to wear the ActiGraph at all times, except when bathing and swimming, for 7 consecutive days. Consistent with previous studies, the ActiGraph was worn on the right hip (mid-axilla line at the level of the iliac crest). Non-wearing time for each monitoring day was calculated by counting the number of zero counts accumulated in strings of 20 minutes or longer. Girls were included in the analyses if they had 4 or more days with 10 or more hours of wearing time (Masse et al., 2005). Previous work has shown that 4 days of monitoring provides reliable estimates of usual physical activity in adolescent youth (Trost, McIver, & Pate, 2005). In this study, 75.2% of girls had 7 valid monitoring days, with 14.3%, 6.8%, and 3.8% providing 6, 5, and 4 valid days, respectively. Among the participants with 4 or more valid monitoring days, daily wear time ranged from 763.4 minutes to 1282 minutes, with an average of 1086 ± 116 minutes.

Raw accelerometer counts were uploaded to a customized software program for determination of total daily counts, and daily time spent in moderate (MPA), vigorous (VPA), and moderate-to-vigorous (MVPA) physical activity. The age-specific count thresholds corresponding to the aforementioned intensity levels were derived from the MET prediction equation developed by Freedson and co-workers (Freedson, 2005; S. G. Trost et al., 2002). To accommodate the 30-sec epoch length, count thresholds were divided by 2 (Nilsson, Ekelund, Yngve, & Sjostrom, 2002).

Statistical Analysis

Path analysis was used to assess predictors and consequences of perceived athletic competence (see Figure 1). All variables were modeled as manifest variables in AMOS 7.0. Age 11 perceived athletic competence and change in perceived athletic competence between ages 11 and 13 were modeled as mediators of the relationship between age 9 variables sport participation (aesthetic and non-aesthetic), adiposity, and breast development and age 13 MVPA as outlined in figure 1. All exogenous variables were allowed to correlate. All age 9 variables were modeled as direct predictors of age 11 perceived athletic competence, change in perceived competence between ages 11 and 13, and age 13 MVPA (In order to simplify the illustration, the latter pathways are not shown in Figure 1). Including paths to both the proposed mediators and the final outcome variable allowed the calculation of direct and indirect effects. Measures of SES self-reported physical activity and perceived competence at age 9 were entered as covariates were due to age 9 variations in SES, physical activity or perceived athletic competence. Model fit was determined using X^2 and three indices of practical fit: RHO (L. R. Tucker & Lewis, 1973), CFI = (Bentler, 1990), and RMSEA (Browne & Cudeck, 1993). Values of RHO<.06, CFI >.90, TLI >.90 were used as cutoffs for acceptable fit (Hu & Bentler, 1995). Mediation was examined using the methods employed by Dishman and colleagues (Dishman et al., 2004).

Results

Sample characteristics

Families in this sample had relatively high levels of education and income. None of the mothers reported less than high-school education. The majority of mothers had some post-secondary education with 26% having earned bachelor's degrees and 15% having earned graduate degrees. The fathers were also well educated with 25% reporting bachelor's degrees and 20% reporting graduate degrees. Families with household incomes over $50,000 made up 57% of the sample.

As shown in Table 1, girls in this study had an average body fat percentage of 26.74% at age 9 and almost half showed no evidence of breast development. Almost 60% of the girls participated in non-aesthetic sports while 30% participated in aesthetic sports. 16% of the girls participated in both aesthetic and non-aesthetic sports. Perceived athletic competence declined significantly ($t(167) = 2.46$, $p = .015$) between ages 11 (M = 2.92, S.D. = .629) and 13 (M = 2.79, S.D. = .654). Finally, girls engaged in an average of 36 minutes per day of moderate-to-vigorous physical activity at age 13

Results of path model

The chi-squared value for the initial analyses indicated that the proposed modeled did not exhibit acceptable fit ($X^2(2) = 43.109$, p= < .001). Further evidence for lack of acceptable model fit was provided by the pattern of values for several indices of practical fit: RHO = -5.963 (Tucker & Lewis, 1973), CFI = .747 (Bentler, 1990), and RMSEA =.379 (Browne & Cudeck, 1993).

One advantage of SEM programs such as AMOS is that errors terms associated with endogenous variables to be correlated (Papaioannous, 2006). The model was rerun allowing errors for age 11 perceived athletic competence and the change in perceived athletic competence between ages 11 and 13 to correlate. This model yielded significantly better fit. The non-significant chi-square value ($X^2(1) = .373$, p=.541) for the tested model allowed us to fail to reject the null hypothesis that the fitted model and the pattern of the observed data were very similar. Further support for acceptable model fit was provided by the pattern of values for several indices of practical fit: RHO = 1.212 (Tucker & Lewis, 1973), CFI = 1.000 (Bentler, 1990), and RMSEA = <.001 (Browne & Cudeck, 1993). The results of the revised model are shown in Tables 2 and 3 and Figure 2. The model accounted for 32% of the variance in age 11 perceived athletic competence, 9% of the variance in the age 11-13 change in perceived athletic competence, and 12% of the variance in age 13 MVPA.

As hypothesized (see Table 2 and Figure 2), participation in aesthetic sports and non-aesthetic sports and lower body fat at age 9 were associated with higher levels of perceived athletic competence at age 11. In contrast to predictions, however, the estimated parameters for non-aesthetic and aesthetic sport participation were not significantly different (non-aesthetic 95% C. I. = .19-.55). Of the covariates, only age 9 perceived athletic competence was a significant predictor of age 11 perceived athletic competence. Higher age 11 perceived athletic competence was, in turn, associated with significantly higher MVPA at age 13, while none of the age 9 variables were significant predictors. Thus, age 11 perceived athletic competence mediated the relationships of age 9 non-aesthetic sport participation (indirect effects = .066), aesthetic sport participation (indirect effects = .039), and percent body fat (indirect effects = -.044) with age 13 MVPA.

Age 9 breast development was the only significant negative predictor of the change in perceived athletic competence between ages 11 and 13. More advanced stage of breast development was associated with a steeper decline in perceived athletic competence between ages 11 and 13. Decreases in perceived athletic competence between ages 11 and 13 were, in turn, associated with lower MVPA at age 13. None of the age 9 variables were significant predictors of age 13 MVPA, indicating that the relationship between age 9 breast development and age 13 MVPA was mediated by the change in perceived between ages 11 and 13 competence (indirect effects = -.072).

Discussion

This study examined predictors and outcomes of girls' level (age 11) of and change (age 11 to 13) in adolescent girls' perceived athletic competence. Although girls in this study reported generally high levels of perceived athletic competence at age 11 (level), their perceived competence declined significantly between ages 11 and 13. Different predictors of level of and change in perceived athletic competence were identified. Congruent with conclusions drawn by Biddle and colleagues (Biddle & Wang, 2003), we found that age 11 perceived athletic competence was a small but significant predictor of age 13 MVPA. Each one unit difference in age 11 perceived athletic competence was associated with a 5.3 minute difference in predicted age 13 daily MVPA. Given the range of perceived athletic competence reported by our participants, a difference of 15 minutes of MVPA per day between the individuals with the lowest and highest perceived athletic competence would be expected to result from the discrepancy in perceived athletic competence.

A similar pattern was observed for the relationship between the age 11 to 13 change in perceived athletic competence and age 13 MVPA. Each one unit decline in perceived athletic competence was associated with a 5.5 minute reduction in predicted daily MVPA at age 13. The discrepancies in change scores observed in our study indicate a 25 minute per day difference in predicted MVPA between those with the greatest decline and the greatest gain in perceived athletic competence between ages 11 and 13.

Interestingly, different predictors of age 11 perceived athletic competence and change in perceived athletic competence between ages 11 and 13 were identified. This finding suggests that different processes influence single time point estimates versus changes across time. In the current case, it is interesting to note that weight status and sport participation, which predicted age 11 level of perceived athletic competence, are factors that exist across the lifespan while pubertal development, which predicted change in perceived athletic competence, is a process of dramatic change over a relatively short time period. Both weight status and sport participation may be part of reinforcing cycles that result in fairly consistent ordering of girls' perceived athletic competence and physical activity levels across time, while pubertal development may act to disrupt these patterns. For example, findings from the current study indicate that higher weight status predicts lower perceived athletic competence, which in turn predicts lower physical activity. These lower levels of physical activity are likely to reinforce higher weight status, thereby maintaining the cycle. An opposite pattern would apply to girls with lower weight status.

In contrast, pubertal development likely represents a different type of process; a process which is capable of altering the status quo maintained by the cycles described above. There is evidence that higher weight status both results from earlier pubertal timing across racial groups (Tremblay & Frigon, 2005) and precipitates early pubertal development in white girls (Davison, Susman, & Birch, 2003; Slyper, 2006). There is evidence, however, that that puberty has impacts beyond those of weight status. There is considerable variation in weight status within pubertal timing groups and obesity and pubertal timing independently predict girls' negative self-evaluations during adolescence (Alsaker, 1992). Findings from this study support the independent contributions of weight status and pubertal development to girls' negative self-evaluations of their athletic competence. In the case of perceived athletic competence, it may be that weight status and sport participation play out in the reinforcing cycles described above, maintaining girls' in approximately the same rankings until puberty. As some girls begin pubertal development earlier that others, different patterns of change in perceived athletic competence develop in girls who were previously similar. For example, two girls who throughout childhood had relatively low weight status and participated in sports would likely have relatively high perceived athletic competence. If, however, one went through puberty early while the other did not, the early maturer would likely exhibit a decrease in perceived athletic competence relative to the other girl.

Contrary to our predictions, there was no statistical difference in the predictive effects of aesthetic vs. non-aesthetic sport participation on perceived athletic competence. It may be that differences in the two types of sports identified in previous research (Monsma, Malina, & Feltz, 2006) do not extend to perceived athletic competence. While aesthetic sports are associated with negative psychological outcomes such as higher weight concerns, risk of eating disorders, and body dissatisfaction compared to non-aesthetic sports (Miller & Levy, 1996), results from this study suggest that aesthetic and non-aesthetic sport participation both contribute positively to perceived athletic competence. Alternatively, the overlap between aesthetic and non-aesthetic sport participation in this sample (50% of those who participated in aesthetic sports also participated in a non-aesthetic sport) may have obscured differences that did exist. Future research using larger sample sizes is needed to examine these possibilities.

This study has a number of strengths and weaknesses. The longitudinal design of the study allowed the examination of predictors and outcomes of both level of and change in perceived athletic competence across time. In addition, the use of an objective measure of physical activity as an outcome reduces the measurement concerns associated with self-reported physical activity. While the study design and measures used were strengths of this study, there were also several limitations. Participants in the study were Caucasian girls residing in central Pennsylvania. Therefore, results may not generalize across geographic areas or ethnicities. In addition, objective measures of physical activity were not available prior to age 13 so it was not possible to examine whether or not changes in perceived athletic competence were predictive of changes in physical activity or to examine the opposite pattern in which changed in physical activity are predictive of changes in perceived athletic competence.

Future research should address these weaknesses by examining the models tested in this study in ethnically and geographically diverse samples. In addition, repeated objective measures of physical activity would allow for changes in physical activity based on perceived competence to be examined. While many of the findings from this study are congruent with previous research, to our knowledge this is the first time that changes in perceived athletic competence have been explored as a predictor of accelerometer measured physical activity. Therefore, future research should attempt to replicate these findings in both similar and dissimilar populations.

Results from this study have implications for practice and intervention. The findings contribute to a small but growing body of literature which, taken together, suggests that perceived athletic competence may be a suitable target in interventions designed to increase physical activity in adolescent girls. In addition, facilitating sport participation may be a key factor in promoting perceived athletic competence. Finally, the negative relationship between body fatness and pubertal development and levels of and changes in perceived athletic competence suggest that doctors, teachers, and parents should pay particular attention to promoting or maintaining sport participation and increasing perceived athletic competence among girls who are overweight or who are entering puberty.

Table 4.1. Descriptive Statistics

Variable	**Mean or Percentage**
Body fat percentage (age 9)	26.74 (7.20)
Perceived athletic competence (age 9)	2.95 (.66)
Self-reported physical activity (age 9)	2.85 (.38)
Breast development stage	1.75 (.77)
Breast development stage 1 (%)	44%
Breast development stage 2 (%)	35%
Breast development stage 3 (%)	21%
Percent non-aesthetic sport participation (age 9)	57%
Percent aesthetic sport participation (age 9)	32%
Perceived athletic competence (age 11)	2.94 (.63)
Change in perceived athletic competence ages 11-13	-.14 (.62)
Minutes of MVPA per day (age 13)	35.93 (14.75)

Table 4.2. Results for Path Model

Outcome	**Predictor**	**b**	**β**	**S.E.**	**C.R.**	**P**
Perceived athletic competence (Age 11)	Non-aesthetic sport participation (age 9)	.370	.293	.090	4.115	**<.001**
	Aesthetic sport participation (age 9)	.229	.172	.094	2.428	**.015**
R^2 = .318	Breast development (age 9)	.092	.112	.078	1.176	.240
	Percent body fat (age 9)	-.017	-.194	.009	-1.978	**.048**
	Socioeconomic status	-.041	-.089	.034	-1.210	.226
	Perceived athletic competence (age 9)	.366	.386	.069	5.332	**<.001**
	Self-reported physical activity (age 9)	.062	.036	.123	.501	.616
Change in perceived athletic competence (PAC) ages 11-13	Non-aesthetic sport participation (age 9)	-.008	-.006	.106	-.078	.938
	Aesthetic sport participation (age 9)	-.198	-.149	.111	-1.791	.073
	Breast development (age 9)	-.252	-.306	.091	-2.770	**.006**
R^2 = .087	Percent body fat (age 9)	.018	.205	.010	1.787	.074
	Socioeconomic status	-.030	-.064	.040	-.745	.456
	Perceived athletic competence (age 9)	-.025	-.026	.081	-.305	.760
	Self-reported physical activity (age 9)	-.094	-.055	.144	-.650	.516
Minutes of moderate-to vigorous-physical activity (age 13)	Perceived athletic competence (Age 11)	5.292	.226	2.343	2.259	**.024**
	Change in PAC ages 11-13	5.469	.234	2.237	2.445	**.014**
R^2 = .119	Non-aesthetic sport participation (age 9)	1.953	.066	2.568	.760	.447
	Aesthetic sport participation (age 9)	1.402	.045	2.546	.551	.582
	Breast development (age 9)	-.214	-.011	2.129	-.101	.920
	Percent body fat (age 9)	-.263	-.127	.236	-1.116	.264
	Socioeconomic status	.412	.038	.916	.449	.653
	Self-reported physical activity (age 9)	3.640	.092	3.223	1.129	.259

Table 4.3. Indirect and Total Effects of Significant Paths Predicting age 13 MVPA

Path	Total Effects		Indirect Effects	
	b	**β**	**b**	**β**
Perceived athletic competence (Age 11)	5.292	.226	N/A	N/A
Change in PAC ages 11-13	5.469	.234	N/A	N/A
Non-aesthetic sport participation (age 9) via age 11 perceived athletic competence	3.868	.131	1.958	.066
Aesthetic sport participation (age 9) via age 11 perceived athletic competence	1.530	.049	1.212	.039
Breast development (age 9) via change in perceived athletic competence	-1.108	-.058	-1.378	-.072
Percent body fat (age 9) via age 11 perceived athletic competence	-.254	-.123	-.005	-.044

Figure 4.1. Hypothesized Model

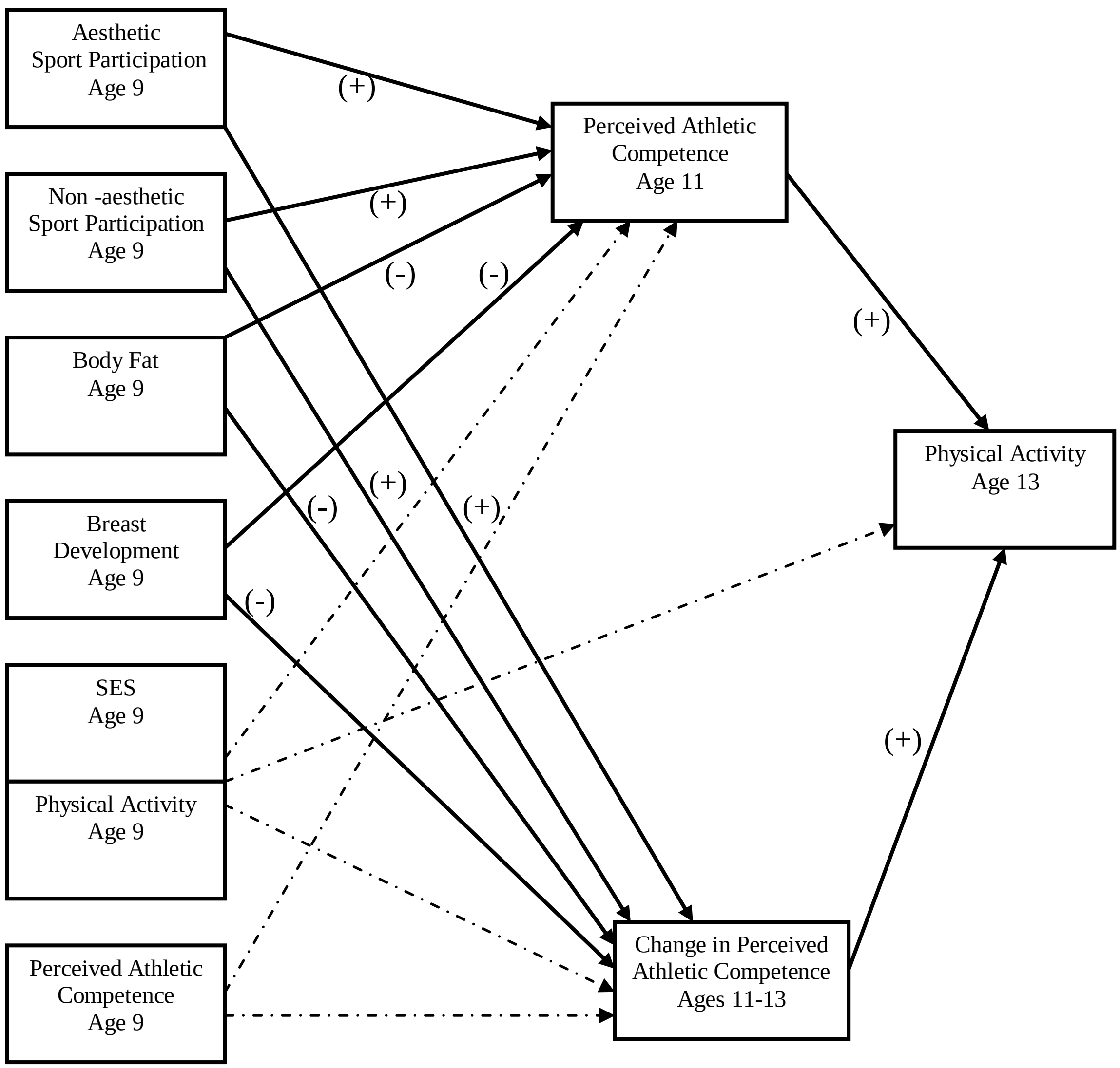
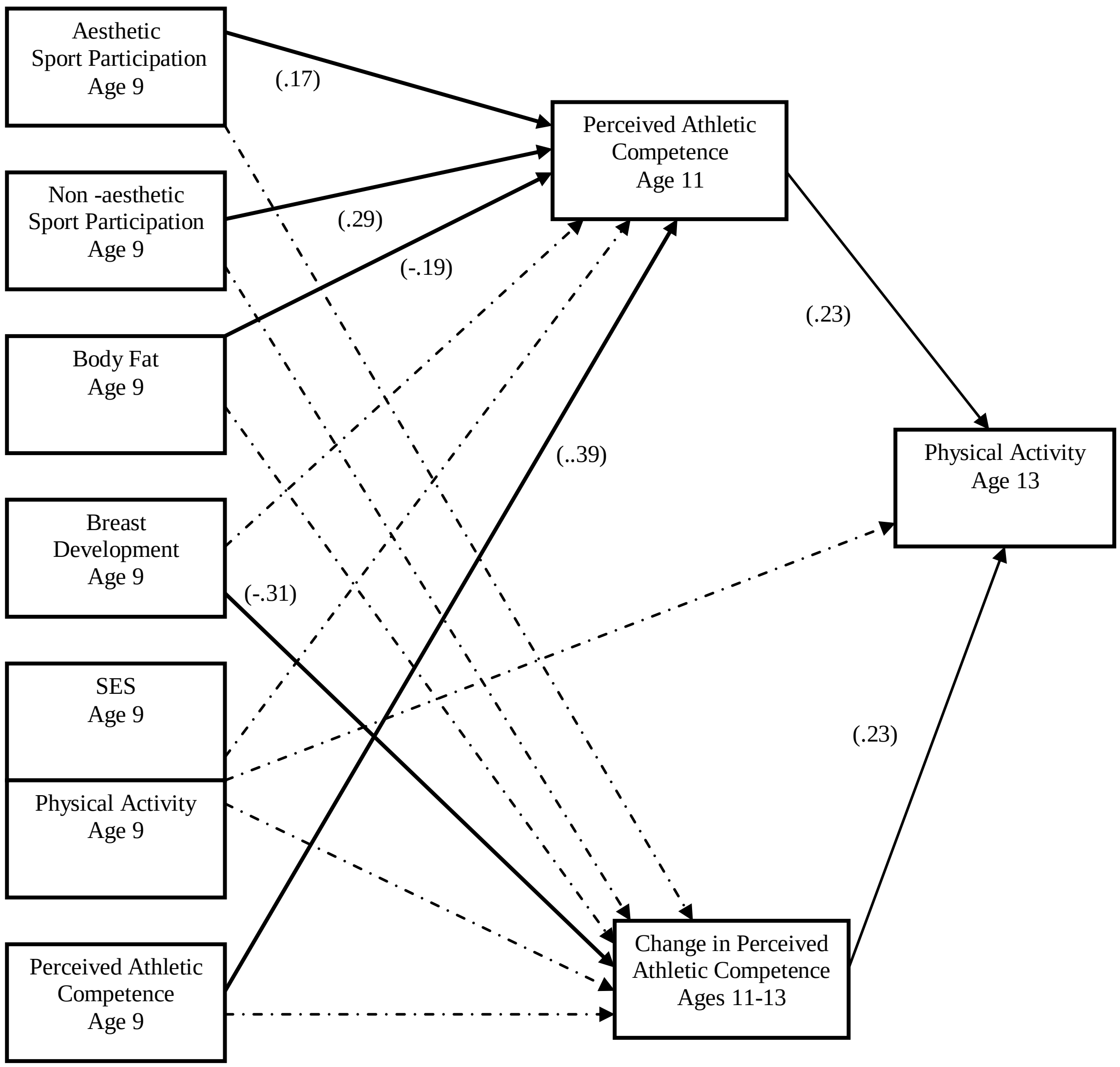


Figure 4.2. Model of Results



Correlations among all predictor (age 9) variables were modeled. Direct paths between all predictor variables except age 9 Perceived Competence and age 13 Physical Activity were modeled.

REFERENCES

Aaron, D. J., Storti, K. L., Robertson, R. J., Kriska, A. M., & LaPorte, R. E. (2002). Longitudinal study of the number and choice of leisure time physical activities from mid to late adolescence: implications for school curricula and community recreation programs. *Archives of Pediatric and Adolescent Medicine, 156*(11), 1075-1080.

Alsaker, F. D. (1992). Pubertal timing, overweight, and psychological adjustment. *The Journal of Early Adolescence, 12*(4), 396.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin, 107*(2), 238-246.

Biddle, S. J., & Wang, C. K. (2003). Motivation and self-perception profiles and links with physical activity in adolescent girls. *Journal of Adolescence, 26*(6), 687-701.

Biddle, S. J., Whitehead, S. H., O'Donovan, T. M., & Nevill, M. E. (2005). Correlates of participation in physical activity for adolescent girls: A systematic review of recent literature. *Journal of Physical Activity and Health, 2*, 423-434.

Caspersen, C. J., Pereira, M. A., & Curran, K. M. (2000). Changes in physical activity patterns in the United States, by sex and cross-sectional age. *Medicine and Science in Sports and Exercise, 32*(9), 1601-1609.

CDCP. (2006). Youth risk behavior surveillance--United States, 2005. *Morbidity and mortality weekly report. CDC surveillance summaries, 55*(5), 1-108.

Crocker, P. R., Eklund, R. C., & Kowalski, K. C. (2000). Children's physical activity and physical self-perceptions. *Journal of Sports Sciences. 18*(6), 383-394.

Davison, K. K., Earnest, M. B., & Birch, L. L. (2002). Participation in aesthetic sports and girls' weight concerns at ages 5 and 7 years. *International Journal of Eating Disorders, 31*(3), 312-317.

Davison, K. K., Susman, E. J., & Birch, L. L. (2003). Percent body fat at age 5 predicts earlier pubertal development among girls at age 9. *Pediatrics, 111*(4 Pt 1), 815-821.

Dishman, R. K., Motl, R. W., Saunders, R., Felton, G., Ward, D. S., Dowda, M., et al. (2004). Self-efficacy partially mediates the effect of a school-based physical-activity intervention among adolescent girls. *Preventive Medicine, 38*(5), 628-636.

Dunton, G. F., Jamner, M. S., & Cooper, D. M. (2003). Assessing the perceived environment among minimally active adolescent girls: validity and relations to physical activity outcomes. *American Journal of Health Promotion, 18*(1), 70-73.

Ellis, K. J., Shypailo, R. J., Pratt, J. A., & Pond, W. G. (1994). Accuracy of dual-energy x-ray absorptiometry for body-composition measurements in children. *American Journal of Clinical Nutrition, 60*, 660-665.

Freedson, P., Patty|Pober,D,David|Janz,KF,Kathleen F. (2005). Calibration of accelerometer output for children. *Medicine and Science in Sports and Exercise, 37*(11 Suppl), S523-S530.

Goran, M. I., Driscoll, P., Johnson, R., Nagy, T. R., & Hunter, G. (1996). Cross-calibration of body-composition techniques against dual-energy X-ray absorptiometry in young children. *American Journal of Clinical Nutrition, 63*, 299-305.

Graber, J. A., Brooks-Gunn, J., & Warren, M. P. (1999). The vulnerable transition: Puberty and the development of eating pathology and negative mood. *Women's Health Issues, 9*(2), 107-114.

Harter, S. (1985). *Manual for the self-perception profile for children*. Denver, CO: University of Denver.

Harter, S. (1988). *Manual for the self-perception profile for adolescents*. Denver, CO: University of Denver.

Hu, L., & Bentler, P. M. (1995). Evaluating model fit. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues and applications*. Thousand Oaks, CA: Sage.

Jacobs, J. E., Lanza, S., Osgood, D. W., Eccles, J. S., & Wigfield, A. (2002). Changes in children's self-competence and values: Gender and domain differences across grades one through twelve. *Child Development, 73*(2), 509-527.

Jago, R., Anderson, C. B., Baranowski, T., & Watson, K. (2005). Adolescent patterns of physical activity differences by gender, day, and time of day. *American Journal of Preventive Medicine, 28*(5), 447-452.

Kimm, S. Y., Glynn, N. W., Kriska, A. M., Barton, B. A., Kronsberg, S. S., Daniels, S. R., et al. (2002). Decline in physical activity in black girls and white girls during adolescence. *The New England Journal of Medicine, 347*(10), 709-715.

Lukaski, H. C. (1993). Soft tissue composition and bone mineral status: Evaluation by dual-energy X-ray absorptiometry. *The Journal of Nutrition, 123*(2), 438-443.

Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). *Growth, maturation, and physical activity* (2nd ed.). Champaign, IL: Human Kinetics.

Marsh, H. W. (1998). Age and gender effects in physical self-concepts for adolescent elite athletes and nonathletes: A multicohort-multioccasion design. *Journal of Sport & Exercise Psychology, 20*(3), 237.

Marshall, W. A., & Tanner, J. M. (1969). Variations in the pattern of pubertal changes in girls. *Archives of Diseases in Children, 44*, 291-303.

Masse, L. C., Fuemmeler, B. F., Anderson, C. B., Matthews, C. E., Trost, S. G., Catellier, D. J., et al. (2005). Accelerometer data reduction: a comparison of four reduction algorithms on select outcome variables. *Medicine and Science in Sports and Exercise, 37*(11 Suppl), S544-554.

Mazess, R. B., Barden, H. S., Bisek, J. P., & Hanson, J. (1990). Dual-energy x-ray absorptiometry for total-body and regional bone-mineral and soft-tissue composition. *American Journal of Clinical Nutrition, 51*(6), 1106-1112.

Miller, J. L., & Levy, G. D. (1996). Gender role conflict, gender-typed characteristics, self-concepts, and sport socialization in female athletes and nonathletes. *Sex Roles*, *35*(1), 111-122.

Monsma, V. E., Malina, M. R., & Feltz, L. D. (2006). Puberty and physical self-perceptions of competitive female figure skaters: An interdisciplinary approach. *Research Quarterly for Exercise and Sport, 77*(2), 158.

Motl, R. W., Birnbaum, A. S., Kubik, M. Y., & Dishman, R. K. (2004). Naturally occurring changes in physical activity are inversely related to depressive symptoms during early adolescence. *Psychosomatic Medicine, 66*(3), 336-342.

National Center for Health Statistics. (2005). *Health, United States, 2005 With Chartbook on Trends in the Health of Americans.* . Hyattsville, Maryland: National Center for Health Statistics.

Nilsson, A., Ekelund, U., Yngve, A., & Sjostrom, M. (2002). Assessing physical activity among children with accelerometers using different time sampling intervals and placements. *Pediatric Exercise Science, 14*, 87-96.

Papaioannou, A., Bebetsos, E., Theodorakis, Y., Christodoulidis, T., & Kouli, O. (2006). Causal relationships of sport and exercise involvement with goal orientations, perceived competence and intrinsic motivation in physical education: a longitudinal study. *Journal of Sports Sciences, 24*(4), 367-382.

Ravaldi, C., Vannacci, A., Zucchi, T., Mannucci, E., Cabras, P. L., Boldrini, M., et al. (2003). Eating disorders and body image disturbances among ballet dancers, gymnasium users and body builders. *Psychopathology, 36*(5), 247-254.

Shapka, D. J., & Keating, P. D. (2005). Structure and change in self-concept during adolescence. *Canadian Journal of Behavioural Science, 37*(2), 83.

Slyper, A. H. (2006). The pubertal timing controversy in the USA, and a review of possible causative factors for the advance in timing of onset of puberty. *Clinical Endocrinology, 65*(1), 1-8.

Sollerhed, A. C., Apitzsch, E., Rastam, L., & Ejlertsson, G. (2008). Factors associated with young children's self-perceived physical competence and self-reported physical activity. *Health Education Research, 23*(1):125-136.

Torstveit, M. K., & Sundgot-Borgen, J. J. (2005). Participation in leanness sports but not training volume is associated with menstrual dysfunction: a national survey of 1276 elite athletes and controls. *British Journal of Sports Medicine, 39*(3), 141-147.

Tremblay, L. L., & Frigon, J. Y. (2005). The interaction role of obesity and pubertal timing on the psychosocial adjustment of adolescent girls: longitudinal data. *International Journal of Obesity, 29*(10), 1204-1211.

Trost, S., Pate, R., Saunders, R., Ward, D. S., Dowda, M., & Felton, G. (1997). A prospective study of the determinants of physical activity in rural fifth-grade children. *Preventive Medicine, 26,* 257-263.

Trost, S. G., Pate, R. R., Sallis, J. F., Freedson, P. S., Taylor, W. C., Dowda, M., et al. (2002). Age and gender differences in objectively measured physical activity in youth. *Medicine and Science in Sports and Exercise, 34*(2), 350-355.

Trost, S. G., Ward, D. S., Moorehead, S. M., Watson, P. D., Riner, W., & Burke, J. R. (1998). Validity of the computer science and applications (CSA) activity monitor in children. *Medicine and Science in Sports and Exercise, 30*(4), 629-633.

Tucker, L. A., Seljaas, G. T., & Hager, R. L. (1997). Body fat percentage of children varies according to their diet composition. *Journal of the American Dietetic Association, 97*(981-986).

Tucker, L. R., & Lewis, C. (1973). A reliability coefficient for maximum likelihood factor analysis. *Psychometrika, 38*(1), 1-10.

Welk, G. J., & Schaben, J. A. (2004). Psychosocial correlates of physical activity in children-A study of relationships when children have similar opportunities to be active. *Measurement in Physical Education and Exercise Science, 8*(2), 63-81.

Wichstrom, L. (1995). Harter's Self-Perception Profile for Adolescents: Reliability, validity, and evaluation of the question format. *Journal of Personality Assessment, 65*(1), 100-116.

CHAPTER 5

SUMMARY AND CONCLUSIONS

This dissertation comprises three studies that shed light on potential reasons for the documented low levels of adolescent girls' physical activity. A majority of girls fail to meet physical activity recommendations throughout adolescence and rates of girls meeting physical activity recommendations decline significantly during adolescence. These trends are of concern because low levels of physical activity are associated with a number of negative health outcomes including obesity, high blood pressure, poor lipid levels, low bone mineral density, and depression. Theoretical frameworks such as the Leisure Course Perspective (LCP) and Social Cognitive Theory (SCT) provide guidance regarding factors that may drive the decline in girls' physical activity. LCP highlights the importance of societal constraints, social networks, and the type and timing of transitions in shaping developmental pathways. SCT adds a focus on the specific cognitive processes through which the societal constraints and social networks of the LCP act to influence behavior. The three studies in this dissertation examined specific transitions (puberty) and cognitive processes (motivation and perceived athletic competence) that are likely to be particularly relevant to adolescent girls' physical activity and addressed three research questions. Results pertaining to the hypotheses associated with each paper and each of the three research questions from the introduction are discussed below:

Study 1

Previous research indicates that early onset of puberty relative to peers puts girls at higher risk for a variety of negative outcomes. The purpose of Study 1 was to examine the relationship between the timing of pubertal maturation and subsequent physical activity. It was hypothesized that girls with more advanced pubertal status at age 11 would have lower levels of physical activity at age 13 when controlling for age 11 weight status. This hypothesis was supported. Results indicated that girls with more advanced pubertal status at age 11 had lower levels of physical activity at age 13 controlling for age 11 body fat percentage and self-reported physical activity.

Study Two

Using Self-Determination Theory (SDT) as a framework, Study Two examined motivations for physical activity. According to SDT, autonomy, relatedness, and perceived competence are precursors of intrinsic motivation which is, in turn, predictive of higher levels of activity engagement. In contrast, an individual whose environment does not meet her needs for autonomy, relatedness, and perceived competence is more likely to report extrinsic motivation which is less predictive of activity involvement. In this study, weight related motivation was examined because an increase in weight concerns is associated with pubertal development in adolescent girls. It was hypothesized that level of extrinsic motivation for physical activity across ages 9 to 13 would be predicted by perceived athletic competence (positive), parental encouragement of autonomy (negative), and quality of relationship with parents (negative) at age 9. In contrast, it was hypothesized that level of intrinsic motivation for physical activity across ages 9 to 13 would be predicted by perceived athletic competence (positive), parental encouragement of autonomy (positive), and quality of relationship with parents (positive) at age 9. These hypotheses were partially supported. Girls with high perceptions of autonomy and competence were more likely to report high levels of intrinsic motivation and low level of extrinsic motivation across ages 9-13. Relatedness was not a significant predictor of level of intrinsic or extrinsic motivation.

It was also hypothesized that girls with consistently high levels of intrinsic motivation across ages 9-13 would have higher levels of physical activity at age 13 than other girls while extrinsic motivation would not be related to age 13 physical activity. This hypothesis was supported. Persistent high levels of intrinsic motivation predicted higher levels of age 13 MVPA, while persistent high levels of extrinsic motivation were not significantly related to age 13 MVPA.

Study Three

Study Three focused on level and change in perceived athletic competence as a mediator of relationships between age 9 body fatness, pubertal maturation, and sport participation and age 13 physical activity. Previous research has indicated that perceived athletic competence is positively associated with physical activity participation. This relationship has not, however, been extensively studied in adolescent girls and little is known about the relationships between perceived athletic competence and biological factors such as puberty and body fatness or sport participation. In addition, the relationship between changes in perceived athletic competence and physical activity has not been examined in adolescent girls.

It was hypothesized that age 9 body fatness (negative), breast development (negative), and participation in aesthetic (positive) and non-aesthetic sports would be significant predictors of age 11 level and age 11-13 change in perceived athletic competence. This hypothesis was partially supported. Age 9 participation in aesthetic sports (positive), participation in non-aesthetic sports (positive), and body fatness (negative) were predictive of age 11 perceived athletic competence in the anticipated directions. Only age 9 breast development was predictive of change in perceived athletic competence between ages 9 and 13.

In addition, it was hypothesized that age 11 level of perceived competence and change in perceived athletic competence between ages 11 and 13 would be positive predictors of age 13 moderate-to-vigorous physical activity. This hypothesis was supported. Both age 11 perceived athletic competence and change in perceived athletic competence between ages 11 and 13 were predictive of age 13 accelerometer-measured physical activity. These relationships were independent of SES and age 9 self-reported physical activity.

Three research questions identified areas of commonalities among the three papers that comprise this dissertation. They are outlined in the following section.

RQ1: Is adolescent girls' pubertal development related to subsequent physical activity?

Puberty appears to play a significant role in adolescent girls' physical activity. In Study One, a more advance pubertal development at age 11 was predictive of lower levels of physical activity at age 13. Results from Paper 3 indicated that more advanced breast development at age 9 was predictive of a steeper decline in perceived athletic competence between ages 11 and 13, which in turn was predictive of lower age 13 MVPA. Both these effects were independent of body fat percent, indicating that the influence of puberty on physical activity cannot be explained by the increases in body fatness associated with puberty.

Paper 1 did not address potential mechanisms by which puberty influences subsequent physical activity. Paper 3 addressed one possible mechanism – perceived athletic competence. Notably, pubertal development predicted the change in perceived athletic competence between ages 11-13, rather than the level of perceived competence at age 11. This suggests that puberty may impact subsequent physical activity by influencing trajectories of intervening variables.

RQ2: Is type of motivation predictive of physical activity in adolescent girls and, if so, what predicts type of motivation?

Results from paper 2 indicate that persistent high intrinsic motivation predicts higher levels of physical activity but that persistent high extrinsic (weight related) motivation does not. In accordance with Self-Determination Theory, both age 9 perceived athletic competence and perceived autonomy were predictive of high persistent intrinsic motivation across ages 9-13.

RQ3: Does adolescent girls' perceived athletic competence predict subsequent physical activity? If so:

a) What are some predictors of perceived athletic competence?

b) Does perceived athletic competence exert influence through intervening variables?

Results from both papers 2 and 3 indicate that perceived athletic competence is positively related to adolescent girls' physical activity. Paper 3 examined predictors of both age 11 perceived athletic competence and the change in perceived athletic competence between ages 11 and 13. Age 9 body fat percentage and sport participation predicted age 11 perceived athletic competence while age 9 breast development predicted the change in perceived athletic competence between ages 11 and 13. Age 13 physical activity was predicted by both age 11 perceived athletic competence and the change in perceived athletic competence between ages 11 and 13. These results suggest that both biological and experiential factors influence perceived athletic competence and that levels of and change in perceived athletic competence independently contribute to physical activity participation. Self-determination theory (SDT) provided the theoretical framework for paper 2 and the predictions of SDT were supported by the results. Girls who reported higher levels of perceived athletic competence at age 9 were more likely to be persistently intrinsically motivated across ages 9-13, which was in turn predictive of higher levels of physical activity at age 13. This indicates that perceived athletic competence may influence subsequent physical activity through intrinsic motivation.

Conclusions

Taken together, these three studies provide insight into factors that influence adolescent girls' physical activity. In particular, findings from these studies highlight the important role that pubertal development and perceived athletic competence play in explaining low levels of physical activity among girls. In addition, the diversity of significant predictors and relationships identified in these three studies emphasize the complexity of the factors that influence adolescent girls' physical activity.

The physiological changes that comprise puberty and the social and psychological changes that accompany them may influence girls' physical activity through a variety of pathways. Increases in body fat percentage and breast development associated with puberty may make physical activity uncomfortable and require preparation (such as ensuring that one is wearing a sports bra) that was not needed pre-puberty. These physiological changes may also create changes in amount of social support or opportunities to be physically active offered by others. For example, increases in body fat associated with puberty may result in real or perceived decreased athletic performance that results in coaches and teachers offering less encouragement. Puberty is also associated with decreases in body esteem and increases in self-consciousness that may make girls reluctant to engage in physical activity for fear it will draw attention to their bodies.

In addition to puberty, results from these studies indicate that perceived competence may play an important role in adolescent girls' physical activity. According to the results of Study Two, perceived athletic competence was a significant negative predictor of extrinsic motivation across ages 9-13 and a positive predictor of intrinsic motivation across ages 9-13, which in turn predicted higher levels of physical activity. In Paper Three, both age 11 perceived athletic competence and change in perceived athletic competence across ages 11-13 were significant positive predictors of age 13 MVPA. In addition to adding strength to the assertion that perceived athletic competence influences physical activity, the findings from Study Three highlight the importance of examining changes in variables across time. These findings suggest that perceived athletic competence may be an appropriate target of intervention.

In addition to the importance of investigating variations across time, these three studies underscore the diversity of factors related to adolescent girls' physical activity. Significant relationships were found between adolescent girls' physical activity and biological (puberty and body fat), psychological (perceived competence and motivation), family (autonomy granting), and contextual (aesthetic and non-aesthetic sport participation) predictors. Elucidation of the factors that influence adolescent girls' physical activity and the relationships among these factors will provide targets for interventions that may slow or reverse the declines in adolescent girls' physical activity.

Future Research

The three papers in this dissertation provide starting points for future research. Refinement of the constructs involved, expansion of the variables included in the models, and application of the methods to other areas of inquiry provide opportunities for extending this research.

The relationship between pubertal timing and subsequent physical activity identified in paper 1 provides a starting point for research regarding possible reasons for this relationship. Puberty is obviously not a factor that is amenable to intervention efforts. Therefore, future research in this area should focus on identifying specifics aspects of the experience of puberty that may exacerbate the decline in girls' physical activity. These may include pre-existing factors such as social support, body image concerns, and previous physical activity participation that may moderate the relationship between puberty and subsequent physical activity and intervening factors such as changes in social support and relative athletic ability that might mediate the relationship between puberty and subsequent physical activity.

Results from paper 2 highlight the importance of examining patterns of motivation across time. A single-item measure of intrinsic motivation was used for this study. This resulted in limited variance that precluded the examination of trajectories of intrinsic motivation. Future research should employ multi-item measures of motivation. In addition, parents' overall, rather than physical activity-specific autonomy granting was examined in this study and found to be related to girls' motivation for physical activity. This suggests that the role of context-specific versus general autonomy granting should be further examined.

Findings from paper 3 indicated that both a point estimate (age 11) and a change score (ages 11-13) of perceived athletic competence predicted age 13 physical activity. In addition, different variables were predictive of level of and change in perceived athletic competence. The years examined in this dissertation are a time of considerable physiological, cognitive, and social change. The pace and direction of changes in each of these domains is likely to influence the pace and direction of changes both within and across domains. Another point for future research is suggested by the Life Course Perspective (Elder & Shanahan, 2006). According to this theory, transitions such as puberty that are times of significant change may result in alterations of previously established patterns of behavior. The degree to which transitions impact subsequent levels of physical activity could be examined by extending the period of time included in this study to encompass other transitions such as leaving school, entering the workforce, and establishing a family.

In addition to the variables examined in these three studies, there are a variety of factors that might influence adolescent girls' physical activity that were not addressed. Biological factors other than puberty and body fat percentage including height, genetic predisposition to fitness, and medical conditions such as asthma were not examined. These factors may influence girls' physical activity participation through self-selection in that girls who are genetically predisposed to higher levels of fitness may find physical activity more enjoyable and be more likely to participate while girls who have a medical condition such as asthma may be less inclined to participate. Physiological factors may also exert influence through their influence on opportunities for physical activity offered to individual girls. In the case of height, taller girls would be more likely to be chosen for selective teams in sports such as volleyball and basketball, while girls who are shorter than average would be more likely to compete at high levels of gymnastics. In addition to these biological factors, a variety of social influences including parents and peer modeling and support of physical activity, and coach and teacher characteristics were also not included in the papers in this dissertation. Finally, community level affordance of physical activity opportunities including access to physical activity facilities and organized sports were not investigated. Research combining these factors with the variables included in this dissertation would provide further insights into the forces shaping adolescent girls' physical activity.

Other important considerations for future research include continuing to employ longitudinal designs, recruiting geographically, ethnically, and socioeconomically diverse samples, obtaining information on a variety of constructs, and using validated measures. The longitudinal design is a significant strength of the three studies in this dissertation. This allowed the examination of changes across time. In cases where variables are not amenable to experimental manipulation (eg. puberty), designs such as this allow some inferences regarding direction of effects to be made. When designing studies, researchers should consider the frequency and timing of measurements to ensure that the intervals are appropriate to the processes being examined.

While the use of longitudinal data was a significant strength of this study, the lack of diversity within the sample was a weakness. Participants in this study were Caucasian, relatively affluent, non-urban girls. The homogeneity of this sample did not allow for the examination of culture, ethnicity, socioeconomic status, or community characteristics in this dissertation. The relationships identified in this study should be examined using geographically, ethnically, and socioeconomically diverse samples.

As mentioned previously, findings from these studies highlighted the complexity of the factors that influence adolescent girls' physical activity. Future study designs should incorporate a range of biological, psychological, family, and community variables in order to reflect this complexity and tease out relationships among variables. Lastly, these studies benefitted from the high quality of many of the measures obtained, including DEXA measured body fatness, accelerometer measured physical activity, and nurse-observed breast development. Future research should continue to use measures such as these.

Implication for Policy and Intervention

As mentioned previously, the homogeneity of the sample limits the generalizability of the results from this study. Significant future research is needed to replicate these findings in other samples of similar demographics and to examine these relationships in demographically diverse samples. If these replication and extension studies indicate that the relationships identified in this dissertation are significant, intervention studies using control groups should be undertaken to provide evidence of a quality that would justify policy decisions.

While results from this study are insufficient to inform policy or justify large scale interventions, results from the current study do suggest some low-cost (in terms of money, time, and potential negative impact) measures that could be implemented prior to full scale intervention studies. In some cases, findings from this study also add to a fairly well established body of literature that would provide sufficient evidence for more intensive interventions. The finding that pubertal development and higher body fat percentage negatively impact subsequent physical activity in this sample indicates that teachers, coaches, and parents should be particularly diligent about providing opportunities and encouragement for physical activity for girls who are experiencing puberty or are overweight. Results from this study indicated that parental support for autonomy is associated with intrinsic motivation, which is in turn associated with higher physical activity levels. This is congruent with research on family relationships that has found age-appropriate autonomy granting to be predictive of a variety of positive outcomes. This would argue for parent education programs targeted at providing parents with the information and skills required to foster appropriate levels of autonomy. Lastly, support in this study for the link between perceived athletic competence and physical activity adds to a growing body of evidence on this topic. Bandura (1997) has explicated several well-established methods of increasing perceived competence which could be used to design interventions focused on increasing adolescent girls' physical activity.

In summary, while not sufficient to inform policy or justify widespread, intensive intervention efforts, the three studies in this dissertation add information regarding predictors of adolescent girls' physical activity to the existing literature. In particular, puberty as a predictor of physical activity has largely been unstudied. Future research should use longitudinal designs, diverse samples, sundry constructs, and quality measures when replicating and extending this research.

Vitae

Birgitta L. Baker

EDUCATION

PhD **The Pennsylvania State University, University Park, PA**
Leisure Studies, Minor in Human Development and Family Studies, 2008

Dissertation: ***Pubertal Timing, Type of Motivation, and Perceived Athletic Competence Predictors of Physical Activity in Adolescent Girls***
Committee: Alan Graefe (co-chair), Kirsten Davison (co-chair), Deborah Kerstetter, Andrew Mowen, Leann Birch

MS **Brigham Young University, Provo, UT**
Youth and Family Recreation, 2004

Thesis: ***Family Differentiation, Family Recreation, and Symptoms of Eating Disorders***
Committee: Ramon Zabriskie (chair), Patti Freeman, Dennis Eggett

BHK **University of British Columbia, Vancouver, BC**
Human Kinetics, Emphasis in Health and Fitness, 2001