The Effect of School Environment on the Association between Sweetened Beverage Consumption, Physical Activity Levels, and Body Mass Index

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Increased sugar-sweetened beverage (SB) consumption and declining physical activity (PA) are linked to the rising obesity rates in children. This study seeks to determine if the transition from elementary to middle school has an impact on the relationships between changes in SB consumption, PA, and body mass index percentile (BMI%). At baseline and two years later, 100 subjects (50 elementary and 50 moving to middle school) reported SB consumption, PA level, and had height and weight measured. Frequency of SB consumption and BMI% did not change over the two-year period within or between groups (p>0.05). PA dropped in the transition group (p<0.0001) and was different from the elementary group at year two (p<0.01). The shift into middle school is an important period during which efforts should be made to maintain PA and prevent SB consumption from rising further.
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CHAPTER I

The Problem

More of America's children have become obese over the past three decades. The National Health and Nutrition Examination Survey (NHANES) reported that the prevalence of overweight children (ages 6-11) was only 4% in 1965 but grew to 13% in 1999 (CDC, 1999). Similarly, the prevalence of obesity in adolescents (ages 12-19) increased from 5% in 1970 to 14% in 1999. Strauss and Pollack (2001) reported that from 1986 to 1996, the prevalence of obesity among African-American children increased 120%. Obesity is now the most common medical condition among children: one in three children is categorized as “at risk of overweight” while one in six is “overweight” (Committee on School Health, 2004). A common tool for screening overweight children is body mass index (BMI), the measurement of weight in kilograms divided by height in meters squared (kg/m²). Those whose BMI is from the 85th to less than the 95th percentile are classified as “at risk of overweight” while a BMI at or above the 95th percentile is classified as “overweight” (CDC, 2000). One of the concerns about this growing epidemic is that adiposity has been shown to track from childhood into adulthood (Serdula et al., 1993). On average, one-third of overweight preschoolers and one-half of overweight school-age children will become obese adults (Serdula et al., 1993). Obesity has been linked to clinical conditions such as heart disease, hypertension,
type II diabetes, and some cancers, and the list continues to grow (Johnston, 1985). Considering the impact these diseases have on a person's life, weight must be managed early in life to prevent obesity and its accompanying diseases.

The increasing numbers of overweight children suggests that they are consuming more energy than they are expending. In order to maintain weight, calories consumed must equal calories expended. An imbalance will result in either weight gain or weight loss. The present study is primarily concerned with the imbalance of excess amounts of calories consumed while not enough energy is expended. Recent studies cite soft drinks and sugary beverages, such as fruit punch and kool-aids, as a link to obesity in children because children consume these drinks as empty calories and do not compensate for the increased calories in their diet (Berkey et al, 2004; Ludwig et al, 2001; Striegel-Moore et al, 2006). Empty calories result in no nutritional gain or feeling of satiety. Consumption of these sugary drinks has tripled over the past thirty years (St-Onge et al., 2003), and those who drink sugar-sweetened beverages (SB) tend to have higher daily caloric intakes than non-SB consumers (Harnack et al., 1999).

On the other side of the energy balance equation, children's PA levels have declined, and they engage in more sedentary behaviors such as watching television or playing video or computer games (Giammatei et al, 2003). Reduction in physical activity (PA) levels as children age increases the likelihood that they will be overweight (Riddoch & Boreham, 1995). Physical activity might have a moderating effect on weight gain from excess calories by expending the extra calories. However, children must maintain or increase activity for this to occur. Evidence from recent studies suggests that
this is not the case. Fewer children participate in physical education (PE) classes at school than a decade ago (Blumenthal et al., 2002). In addition, activity levels decline as children age (Brodersen et al., 2007).

Moving from elementary to middle school in North Carolina presents more opportunities for consuming sugar-sweetened beverages and fewer opportunities to engage in physical activity. In North Carolina, vending machines are not allowed in elementary schools but are present in middle school. Across the nation, vending machines are becoming more prevalent in middle and high schools (Fried & Nestle, 2002). In 2002, 60% of US middle and high schools had soft drink vending machines, and exclusive “pouring rights” contracts were signed in an estimated 240 school districts. In other words, major soft drink companies such as Pepsi or Coca-Cola were given exclusive rights to distribute their brand's drinks in the school. Physical education requirements also change from multiple days of physical education and daily recess to likely fewer days of PE (personal communication with Tara Blackshear, M.Ed, Physical Activity Coordinator for the Healthy Study, March 30, 2007). The middle school environment is therefore more conducive to unhealthy behaviors such as drinking more soda and not participating in PE classes, perhaps causing increases in weight. Could measures in decreasing SB consumption and increasing PA levels among America's youth help alleviate the growing numbers of obese children?

Statement of the Problem

The purpose of this study is to determine if the transition from an elementary to a middle school environment has more of an impact on the relationship between changes in
Research Questions (RQ) and Hypotheses

RQ1) Are changes in SB consumption associated with changes in BMI percentile?

   Hypothesis: SB will be positively associated with changes in BMI percentile.

RQ2) Do PA levels moderate the relationship between ΔSB and ΔBMI%?

RQ3) Does a change in school environment affect changes in SB, PA, or BMI%?

   Hypothesis: As children age, school environment changes will be associated with larger increases in SB, decreases in PA, and increases in rates of obesity.

RQ4) If the RQ3 hypothesis is true for significant differences in the ΔBMI%, can the difference in ΔBMI% be related to ΔSB and ΔPA?

Definition of Terms

1. Sugar-sweetened beverage (SB) includes regular soda, fruit-flavored soda, fruit juice, and kool-aid. The drinks' primary ingredients are sugars such as high-fructose corn syrup.

2. Elementary group defines the students who began data collection in 3rd grade and finished in 5th grade.

3. Transition group defines the students who began data collection in 5th grade and finished in 7th grade.
Assumptions

1. BMI increases naturally with age for children and adolescents due to normal growth patterns. By examining BMI percentile, it is possible to determine if a child has maintained, gained, or lost weight in relation to peers.

2. Children completed the questionnaires honestly and accurately for beverage consumption and levels of physical activity.

Delimitations

1. The cohort chosen for this study consisted of students who began during 3rd and 5th grade and finished data collection in 5th and 7th grade, respectively. This range provides data on students who spent the entire period in elementary school (grades 3-5) as well as students who moved from an elementary school to a middle school (grades 5-7).

2. The PA levels examined are habitual activity, not the last seven days.

3. The schools are located in rural North Carolina.

Limitations

1. This is a retrospective study and therefore methods for data collection cannot be altered.

2. The SB and PA data are self-reported.

3. SB is measured by frequency, not amount of the beverage. Due to the age of the subjects, they could mistake a glass of soda as one drink when the beverage represents multiple servings. Likewise, calories per serving size can be different between various sweetened beverages.
4. Because the children are all from rural North Carolina schools, the findings might not be applicable to urban environments.

Significance of the Study

This study will expand on past studies that examined children's beverage consumption or physical activity in relation to body weight because it adds consideration of the effect of school environment. Comparisons between elementary and transition groups could highlight the importance of school environment. As boys and girls move into adolescence, their dependency on their parents decreases and dependency on peers increases (Steinberg & Silverberg, 1986). This shift is important since choices of diet and activity could coincide more with friends' choices. If significant associations between SB, PA, and BMI% are found, this study could demonstrate the necessity to take more action in schools for youth to be more physically active and limit consumption of sugar-sweetened beverages as they progress through school.
CHAPTER II

Review of Literature

Childhood obesity is the result of many factors, such as declining physical activity, increasing television-watching, growing portion sizes, sugar-sweetened beverages, and increased consumption of fast food (Murray et al., 2005). However, the relationship between sugar-sweetened beverage (SB) consumption and physical activity (PA) has not been as thoroughly examined. These two factors have not often been separated by school groups to examine the impact of the changing school environment. This review will focus on three factors: SB consumption, physical activity, and school environment. The first section will provide an overview of studies examining beverage consumption in children. Some studies have found that beverage consumption is an important factor contributing to obesity while others claim no relationship. Besides increasing soda intake, America's youth are also becoming more sedentary (Crespo et al., 2001). The second section of this review will focus on how PA plays an important role in preventing obesity. The third section of this review will discuss the impact of schools in shaping children's behavior.

Sweetened Beverage Consumption

The number of calories from SB per day has increased over the past 30 years (Nielsen & Popkin, 2004). Researchers examined data from four national surveys,
ranging from 1977 until 2001, with a total of 73,345 participants. The data was collected via in-home interviews, 24-hour recalls, and 1-day food records. The authors found that increases in soda consumption have resulted in daily caloric intake nearly tripling from 50 kcal/d to 144 kcal/d (Nielsen & Popkin, 2004). Besides drinking more calories, studies have found that the children's nutrient intake is lower when they consume SB. Striegel-Moore et al. (2006) analyzed data from the National Heart, Lung, and Blood Institute Growth and Health Study (NGHS) to examine changes in their consumption of beverages, BMI, and nutrient intake over 10 years. Three-day food diaries were collected annually from 2,379 Caucasian and African-American girls, starting at age nine or ten. Milk consumption decreased and soda consumption increased for both races as they aged.

Whether or not these increased calories are compensated for in the diet is up to speculation. Harnack, Stang, and Story (1999) conducted a study among 1,810 children, ages two to ten years old, to determine energy intake differences. Of the school-age children, those who drank SB had higher daily energy intakes (2,018 kcal/day) as opposed to the non-SB consumers (1,830 kcal/day). The increase in total daily energy intake with SB consumption could be due to inadequate compensation for liquid calories. DiMeglio and Mattes (2000) designed a study that consisted of two 4-week periods separated by a 4-week washout period. During the testing phases, 15 adult subjects (22.8 ± 2.7 years old) consumed 1883 kilojoules per day of either liquid (soda) or solid (jelly beans) carbohydrate. The results showed a compensation of 118% in free-feeding intake for the jelly beans but no change for free-feeding intake when consuming the liquids. Thus, consumption of SB does not result in a compensatory decrease in other sources of
Sugary drinks, such as sodas, are a source of “empty calories,” a food that lacks nutritional value and does not satiate hunger. Because sodas do not contribute to satiety, adding a soda per day to the diet might result in weight gain over time due to added calories but no compensatory decrease in other foods. DiMeglio and Mattes (2000) found BMI and body weight increased significantly (p<0.05) only during the phase when subjects were given liquid. Although Dimeglio and Mattes' study was conducted with adults, similar results for increased SB consumption leading to weight gain have been found with children. In a study of 16,771 children across the United States, those who increased SB servings/day also experienced increased in BMI of .04 kg/m² per additional daily serving (Berkey et al., 2004). The investigators used data from the U.S. Growing Up Today Study collected from children ages nine to 14-years-old over two one-year periods.

Phillips et al. (2004) also support the fact that SB consumption, specifically soda, is associated with weight gain. Their study involved 192 non-obese girls (ages 8-12) analyzed energy-dense snack foods (EDS) and relative weight status. The girls were enrolled from 1990-1993, participated in annual follow-ups, and were followed until four years post-menarche. The study was not limited to soda but found that soda was the only factor associated with change in BMI Z-score (p=0.001). Striegel-Moore et al. (2006) had a similar finding, for of all the beverages in their study (milk, diet and regular soda, fruit juice, fruit-flavored drinks, and coffee/tea), only soda was associated with BMI (p<0.05).
One of the most cited studies among the beverage and obesity literature is by Ludwig, Peterson, and Gortmaker (2001). This longitudinal study was conducted in 1995-1997 in 548 sixth and seventh graders in four Massachusetts public schools. The researchers found that consumption of one additional SB increases likelihood of obesity 1.6 times (p=0.02). Also, changes in BMI were positively associated with changes in SB (p=0.03, no R² reported), controlling for confounding variables (dietary variables, physical activity, television viewing, and total energy intake). Their research provides evidence that SB could be a key factor affecting children's weight status.

The above studies show support for increased SB being related to increased weight status, but not all studies agree. A study by Ebbeling et al. (2006) explored whether decreasing SB would also be related to decreasing weight status. The researchers conducted a randomized, controlled pilot study that suggests that decreasing SB consumption can have beneficial, weight-reducing effects for adolescents. The 25-week study consisted of 103 adolescents, ages 13 to 18 with a BMI above the 25th percentile, randomly assigned to either a control group or intervention group. The control group maintained typical consumption behavior, whereas the intervention group received home deliveries of noncaloric beverages to displace SB. The primary measures were change in SB consumption and change in BMI between groups. Although overall results for change in BMI were not significant (intervention= 0.07 ± 0.14 kg/m², control= 0.21 ± 0.15 kg/m²; net difference= -0.14 ± 0.21 kg/m²), significant differences emerged with baseline-BMI as a modifier (p = 0.016). Subjects in the upper baseline-BMI tertile had BMI changes that differed significantly between groups (intervention= -0.63 ± 0.23
kg/m², control= 0.12 ± 0.26 kg/m²; net difference= -0.75 ± 0.34 kg/m²). The researchers recognized that many complex genetic, environmental, and behavioral issues complicate the results for this reason.

Forshee and Storey (2003) used data from the Agriculture's Continuing Survey of Food Intake by Individuals to perform descriptive and multivariate regression analyses of beverage consumption and body weight in children. The sample included 1,687 male and 1,624 female children (ages 6-11) and adolescents (ages 12-19), and the focus was on consumption of milk, juices, fruit drinks and punch, and carbonated soft drinks. Analyses were divided by age, race (African-American, Caucasian, and Hispanic), and gender. Their findings indicate no association between BMI and regular soft drinks, but a slight positive association with diet carbonated beverages (p=0.05, no R² reported). Like Striegel-Moore et al. (2006), Forshee and Storey found that African-Americans consumed less of any beverage compared to Caucasian counterparts, and milk consumption for all groups decreased with age. Caucasian adolescent boys (ages 12-19) drank the most carbonated beverages of any group, approximately 1.8 12-ounce servings per day. The researchers concluded that their investigation shows carbonated beverages are not the cause of weight gain in children and adolescents.

A longitudinal study by Newby et al. (2004) looked at 1,345 low-income preschool children in North Dakota. The children had two clinic visits six to 12 months apart. When results were adjusted for age, sex, energy intake, change in height, and sociodemographic variables, the researchers found no significant relationship between weight gain and the intakes of any liquids (fruit juice, p=0.28; fruit drinks, p=0.28; milk,
p=0.86; soda, p=0.95; diet soda, p=0.82). Although the researchers attempted to examine change over time, the period could have been too short to yield significance. However, a longer, 48-month study of 72 children, ages two through six years old, showed that longitudinal juice intake was not associated with overweight (Skinner & Carruth, 2001). The analysis focused on the relationship of fruit juice intake (100% juice) with growth parameters (height, weight, BMI, and ponderal index). The investigators used three-day dietary recalls, collected at in-home interviews every six months for a total of seven interviews. Though juice intake decreased and less nutritious beverage consumption, such as carbonated beverages, increased as the children aged, no significant relationships were found with juice intake and BMI.

A two-year study by Blum, Jacobsen, and Donnelly (2005) shows SB consumption does not differ among subjects according to weight status. Their study consisted of 166 children in third through fifth grade who had their total caloric intake (kcal), beverage consumption (fluid ounces), and BMI Z-scores taken at baseline and year two. A 24-hour recall was used to collect the caloric intake and beverage consumption for milk, 100% juice, diet soda, and sugar-sweetened drinks (regular soda, Hi-C, sports drinks, kool-ade, fruit flavored drinks, iced tea, hot chocolate). BMI Z-scores were used to classify children as overweight (BMI Z-score \geq 1.0) or normal weight (BMI Z-score <1.0) at baseline and year two. Using paired t-test to determine differences between baseline and year two, the researchers found that all subjects and those who remained normal weight significantly decreased milk consumption and total caloric intake and increased diet soda consumption. Children who gained weight did not
significantly alter consumption behavior though increases in diet soda approached significance (p=0.058). Correlation analysis revealed an inverse relationship between change in milk consumption and change in SB consumption from baseline to year two for all subjects (r = -0.27, p<0.05), normal weight subjects (r= -0.29, p<0.05), and subjects who gained weight (r= -0.63, p<0.05). The authors could only speculate that sugar-sweetened beverages were displacing milk, but their results suggest the shift away from milk and over to SB occurs at an early age.

This body of knowledge that developed over the past ten years highlights how poor dietary habits form at a young age. SB consumption and consequently caloric intake rises while nutritional value declines. However, the effect that SB consumption behavior has on weight status is still debatable due to the mixed research findings. A different area that has less debate is the relationship of physical activity and maintaining weight. In order to maintain a healthy weight as energy intake increases, PA must increase to expend the excess calories. The next section will elaborate on research concerning PA in children.

Physical Activity in Children

Children now engage in several forms of play that were not available to children decades ago, such as computers and video games. The shift in use of recreation time for sedentary entertainment instead of physical activity and the awareness that youth are obese at younger ages has spurred many studies. This section will highlight the patterns in physical activity in youth and review the studies that have focused on the relationship of leisure activities with weight status in children.
Longitudinal studies have shown that children are less active as they age. Brodersen et al. (2007) conducted a five-year study with 5,287 male and female British children starting at ages 11-12. The children reported number of days per week of vigorous activity (sweating, breathing hard) and hours of sedentary behavior (watching television, playing video games) at baseline and year five. The researchers found a significant reduction in the mean number of days for vigorous activity per week (males= -1.06 d/wk, females= -1.82 d/wk, p<0.001) and significant increases in hours of sedentary behavior (males= 2.52 h/wk, females= 2.81 h/wk, p<0.001). An earlier study by Aaron et al. (2002) had similar trends for decreases in PA in their four-year study. In this study, 782 adolescents, ages 12 to 15 at baseline, reported hours per week of PA, number of reported activities, and whether they participated in selected activities. Over the four years, PA declined by 26% (p=0.000), and the number of reported activities also fell 56% (p=0.000). The probability of maintaining participation in a specific activity was low to moderate (females= 0.02 to 0.47; males= 0.04 to 0.71). Both Brodersen et al. (2007) and Aaron et al. (2002) assert that interventions are needed to initiate activity at early ages and that efforts be made to maintain those activities.

With the increased time spent in sedentary activities, researchers have found a corresponding increase in children's weight. Crespo et al. (2001) used data from the third National Health and Nutrition Examination Survey (n= 4,069 youth; 1998-1991) to find the relationship between television watching (hours/day), PA (times/week), energy intake (calories/day), and obesity (BMI ≥ 95th percentile). The investigators found that increased hours watching television was associated with a higher prevalence of obesity in
Additionally, watching five or more hours of television was related to the highest prevalence of obesity overall, as compared to children who watched ≤ 1 hr/d, controlling for age, race/ethnicity, and family income (boys' odds ratio 2.63; girls' OR 2.53). Eighteen percent of the children who watch five or more hours per day were obese whereas only 8% of the children who watch less than one hour per day were obese. The energy intake for girls increased 175 kcal per hour of television watched. Increased energy intake in combination with time spent sedentary could explain the increased prevalence of obesity. However, no consistent association between weekly bouts of vigorous activity and prevalence of obesity was found.

Similar results were found by Berkey et al. (2000) in a one-year longitudinal study of 6,149 girls and 4,620 boys, ages 9-14 yrs. Girls in this study also increased BMI in the following circumstances: decreased activity (0.0284 ± 0.0142 kg/m²/hr/day of activity), reported more time being sedentary such as watching television or playing video games (0.0372 ± 0.0106 kg/m²/hr/day). Berkey et al. noted that although the increases are small, the compilation over time would cause the adolescent to experience considerable weight gain. For each 100 kcal/d, participants experienced small increases in BMI (girls: 0.0059 ± 0.0027 kg/m²; boys: 0.0082 ± 0.0030).

Support for Berkey et al.'s assertion that small increases in BMI lead to significant weight gain was provided by Kimm et al. in 2005. They followed 2,379, 9- to 10-year-old girls for nine years. The girls were categorized by race (African-American or Caucasian) and as either active, moderately active, or inactive according to habitual activity questionnaire (HAQ) scores (MET-times per week). Researchers assessed
activity level at years 1, 3, 5, and 7-10 and measured BMI and sum of skinfolds annually. Though the girls in the three groups all started with only small differences in weight (four to five pounds), the gap between groups widened with time to 10-15 pounds, between inactive and active groups. At the end of the study, active girls had significantly lower BMIs than those who were inactive (African-American: 2.98 kg/m² less, Caucasian: 2.10 kg/m² less, p<0.001). The gains were attributed to increased caloric intake and declining physical activity levels.

**Physical Activity and Beverage Consumption Patterns**

When considering factors that contribute to childhood obesity, no single factor can be isolated out as the primary cause. Studies have examined the relationship between PA and SB and their effect on weight status in youth. Giammattei et al. (2003) assert those who consume more SB calories are more likely to engage in sedentary activity. They found that among 385 11- to 13-year-old children, soft drinks (both diet and regular) consumed and time watching television were both significantly associated with being “at risk of overweight” (BMI ≥ 85th percentile). The researchers note that eating can commonly accompany television-watching, so children who gained weight, but drank diet sodas, could be consuming excess calories from snacks. This theory is supported by Matheson et al. (2004) who found that children ate food more often while watching television than while participating in other activities, and a significant portion of daily energy intakes was consumed during television watching.

One study that offers a different perspective on PA and consumption levels is Ondrak et al. (2006). They examined the relationship between activity level (low or
high) and beverage choices and daily consumption among middle and high school students. In both the middle and high school groups, a greater proportion of the highly active group consumed beverages of all types compared to the low active group: water (78% vs. 60%, p=0.03), soda (43% vs. 33%), fruit punch (50% vs. 29%, p<0.005), fruit-flavored soda (40% vs. 26%, p=0.002), and coffee and tea (41% vs. 27%). Milk consumption decreased from middle school to high school, which agrees with other studies (Blum et al., 2005). These findings highlight that activity level could influence the level of beverage consumption. Higher activity will expend energy consumed from drinks. Therefore, whether or not a child who drinks many beverages would gain weight might then depend on how active they are.

Researchers sought to examine the relationship of PA and SB intake on total body fat mass in young males and females over seven years (Mundt et al., 2006). Participants were from eight age cohorts, ranging in age from eight to 15 at baseline, as part of the University of Saskatchewan's Pediatric Bone Mineral Accrual Study. Body composition was measured via dual energy x-ray absorptiometry (DXA). The Physical Activity Questionnaire for Children and 24-hour recalls were administered for obtaining yearly averages of PA and SB intake. The researchers found that among the 227 subjects, only PA level was negatively related to FM development in males (p<0.05). No relationship existed between SB consumption and fat mass development in either sex (p>0.05). Level of activity and maturation processes are possible reasons why SB and children's fat mass development are not related (Mundt et al., 2006). They postulated that part of the reason that SB and FM had no relationship could be due to the higher energy
requirements of the growth process in adolescents warding off fat mass increases. These researchers concluded that PA can negatively affect fat mass accumulation in males but higher intakes of SB are not linked to fat mass accumulation.

The aforementioned studies have examined the effects of either SB or PA on children's body mass and possible interactions of SB and PA. Studies on SB consumption and children's weight have mixed findings, while studies examining PA, sedentary activities, and weight status have generally found that inactivity is associated with or can lead to weight gain.

School Environment

One departure from the literature that the present study seeks to explore will be the possible impact of the school environment on SB consumption, PA, and weight status. Children develop lifestyle and behavior choices during the age they attend school that will carry through to adulthood (Carter, 2002). Carter asserts that school policy, such as physical activity participation requirements, after-school programs, and health-related programs, can help prevent childhood obesity. This section will review findings on school-related beverage consumption and physical activity. The current practices of North Carolina schools will also be discussed.

A policy statement by Committee on School Health (2004) calls for several steps in public schools to decrease youth's soft drink consumption, such as eliminating sources of SB, creating school nutrition advisory councils, and tempering the use of vending machines if a contract is already in place. The committee aims to promote an ideal nutritional environment at schools. According to the American Academy of Pediatrics'
Committee on School Health, soft drink consumption has risen 300% over the past 20 years (1965-1996). Furthermore, 56% to 85% of children consume one or more soft drinks per day in school. In light of concerns about the prevalence of obesity in children, decreasing SB consumption in schools might be one way to counter excess added sugar in the diet since schools can control what they offer to students.

The role of vending machines in SB consumption in schools has been explored by Forshee, Storey, and Ginevan (2005). They used a risk analysis model to determine whether a relationship exists between regular carbonated beverage consumption from school vending machines and BMI. The data came from the Continuing Survey of Food Intake by Individuals (CSFII), the National Health and Nutrition Examination Survey 1999-2000 (NHANES), and the National Family Opinion WorldGroup Share of Intake Panel [sic] study 2001-2002 (NFO-SIP), restricting the age range to 13 to 18 years old. The CSFII allowed researchers to narrow down beverages consumed at school from vending machines, but the NHANES did not specify the source. The NFO-SIP was also used because participants kept food diaries for two weeks, tracking beverage consumption and location consumed. This group consisted of 2,716 participants, ages 12 to 18. The researchers found that in any data set, BMI is not affected by the consumption of regular carbonated soft drinks (RCSD) out of school vending machines. In the CSFII analysis, the researchers found that males consume approximately 590 g/day of regular carbonated soft drinks but on average only 28 g, about 1 ounce, was out of a vending machine. Females exhibited similar RCSD consumption patterns. They consumed a mean total 359 g/d, of which only 16 g was from a vending machine. For both sexes,
over half of the mean RCSD consumption was at home. The American Academy of Pediatrics study previously mentioned cited that more children are drinking soft drinks at school, but Forshee, Storey, and Ginevan's study suggests that the increase in consumption or BMI may not be due to vending machines.

The other issue in the school environment related to the current study is physical activity. Children are less active at older ages, but the decline is not linear, according to Trost et al. (2002). They conducted a cross-sectional study with a survey sample of 1,110 male and female students evenly divided amongst four grade groups (1-3, 4-6, 7-9, 10-12). From this sample, a total of 375 students also divided amongst grades were randomly chosen to use accelerometers to monitor 5-, 10-, and 20-minute bouts of activity for seven consecutive days. The researchers found daily moderate-to-vigorous physical activity (MVPA, >3 METS) and vigorous physical activity (VPA, >6 METS) displayed a significant inverse relationship with grade level for both genders. Grades 1-3 and 4-6 exhibited the largest grade group differences for MVPA (male: 40%, female: 48.8%) and VPA for females (55.6%). The accelerometer data showed 5-, 10-, and 20-minute bouts of MVPA activity also had a significant inverse relationship with grade level, with the largest differences emerging between grades 1-3 and 4-6. The researchers concluded that elementary school children are more active than their middle and high school counterparts, and the greatest age-related decline in activity occurs in elementary school years rather than teen years. The researchers stress that more longitudinal studies need to be conducted comparing elementary school age children to other age groups.

The American Medical Association notes that the percentage of students attending
daily physical education (PE) classes has dropped from 42\% in 1991 to 32\% in 2001 (Blumenthal et al., 2002). Not only has PE participation decreased in general, but it also decreases with age (Gordon-Larsen et al., 2000; Trost et al., 2002) Gordon-Larsen et al.'s study consisted of 17,766 middle and high school students from the 1996 National Longitudinal Study of Adolescent Health. The participants answered questionnaires about hours/week of inactivity (television and video/computer games) and times/week of moderate to vigorous activity. Gordon-Larsen et al. (2000) found that participation in a school PE program is highly associated with the likelihood of participating in moderate to vigorous activity (adjusted odds ratio: 2.21; confidence interval: 1.82-2.68), but only 21.3\% of all adolescents in the study participated in one or more days of PE at their school. Their findings support PE as an effective means to increase activity level but show that students are not engaging in PE much at school.

Elementary and middle schools are drastically different environments for students as far as beverage availability and physical activity requirements. In North Carolina, vending machines are not allowed in elementary school but are present in middle schools. Students who take advantage of this new availability for SB could be taking in excess calories. At the same time that SB increases, structured PA opportunities decrease. North Carolina elementary school children generally engage in physical activity class one day per week plus daily recess, adding up to PA at least five times per week (Tara Blackshear, M.Ed., Physical Activity Coordinator for the Healthy Study, personal communication, March 30, 2007). In contrast, middle schools have flexibility to choose when they will hold PE, which could be implemented as every other week, only one
semester of the year, or alternate three weeks of PE with one week of health education. The disparities in elementary and middle schools appear to be in direct contrast to policies encouraged by the American Pediatric Association to boost the nutritional and active environments for students. Inactivity and excess caloric intake in younger years could possibly have grave consequences later in life. Studies that explore the tracking of childhood obesity into adulthood will be discussed in the next section.

Tracking Obesity into Adulthood

Studies present mixed findings as to whether childhood obesity will track into adulthood and cause later health problems. One study that suggests that childhood weight status does not necessarily determine adult weight status was Wright et al. (2001). Wright et al.'s study (2001) used the Newcastle thousand families birth cohort to examine 529 people's BMI at ages 9, 13, and 50. Repeated measures analysis found no correlation between BMI and age. The leanest children became some of the most obese adults. Only children who were overweight at age 13 showed an increased risk for adult obesity. While Wright et al. (2001) is one example of studies that did not show significant results, other studies have found that childhood obesity has health implications for later life. On average, one-third of overweight preschoolers and one-half of overweight school-age children will become obese adults, according to a review of 17 studies conducted by Serdula et al. (1993). Because many factors, including genetics, are responsible for determining weight, the present study will look at modifiable factors as a means to prevent or treat obesity.

A recent longitudinal study by Yang et al. (2006) found a link between childhood
PA and adulthood obesity. These authors showed that initiating and sustaining physical activity at younger ages can be a means to decrease risk of obesity into adulthood. The researchers used data from the population-based Cardiovascular Risk in Young Finns Study, focusing on four cohorts of men and women who were 9, 12, 15, and 18 years old in 1980. In 2001, the researchers gathered follow-up data for 1,319 of those subjects. Using a physical activity index score from a questionnaire, subjects were classified into tertiles as either “active,” “moderately active,” or “inactive” in both 1980 and 2001. If the classification at both time points was the either “active” or “moderately active,” a subject was deemed “persistently active.” Those whose activity status declined to a different percentile category were classified as “decreasingly active,” and subjects who were “inactive” at both time points were “persistently inactive.” Obesity measures included BMI, sum of skinfolds, and waist circumference. Decreasingly active women from youth to adulthood had higher probability of being overweight (OR=1.79, CI 1.02-3.16) and obese (OR=2.09, CI=1.03-4.26) compared to women who had been persistently active. Persistently inactive women also had higher probability of being overweight than the persistently active women. Mild to severe abdominal obesity was also found to be more likely in decreasingly active men and women compared to those who were persistently active. The researchers' main conclusion was that the development of adulthood obesity could be influenced by physical activity pattern changes from youth. The present study will build on Yang et al.'s work and investigate the effect of a change of school environment and its influence on physical activity patterns.
Summary

The present study seeks to examine changes in SB consumption and PA and their relationship on changes in children's weight status. Past literature is mixed as to whether obesity is related to SB consumption, but studies generally support low or declining PA as an important factor linked to childhood obesity. The present study departs from past approaches by examining the longitudinal changes in a group of elementary school versus middle school children. Comparing the levels of SB consumption and PA between school groups can provide clues for how the environment may impact the health of a child. Obesity at young ages has been shown to track into later adult life (Serdula et al., 1993), so early measures are necessary to prevent obesity and consequent health problems. Differences in changes in SB and PA between a group in elementary school versus a group who moved into middle school will provide evidence for where preventative measures are needed most.
CHAPTER III

Methodology

Subjects

The subjects for this study were recruited from four rural North Carolina schools as part of the Cardiovascular Health in Children (CHIC) Study (McMurray, 2000). Packets with CHIC information and University, IRB approved consent (parents) and assent (children) forms were sent home to parents through the mail and brought home by the children. Those who completed these forms were enrolled in the study. A total of 1,433 subjects were originally enrolled, of which 1,079 subjects had follow-up data two years later. This study is a secondary analysis that has randomly selected 100 subjects from those who had both data points. The elementary group (n=50) were students enrolled in third grade with follow-up data collected in fifth grade whereas the transition group (n=50) started in fifth grade with follow-up data collected in seventh grade.

Instrumentation

Beverage consumption levels were obtained through an Eating Habits Questionnaire (EHQ), in which children reported how often (never to numerous daily) they consumed different drinks. The beverages analyzed in this study were the sugar-sweetened beverages, such as regular and fruit-flavored sodas, fruit juices, and kool-aids. Habitual physical activity levels (PA) were estimated by using a seven-day activity recall
that listed 32 common activities configured to youth in North Carolina. The students selected how many times they participated in each activity for at least 15 minutes within the past seven days (never to daily). Gilmer et al. (1996) demonstrated that this recall has good internal consistency ($\alpha = 0.74$) and test-retest reliability ($r = 0.70$).

Height was measured in centimeters (cm) with a stadiometer (Perspective Enterprises, Kalamazoo, MI). Body mass was measured in kilograms (kg) with a calibrated balance-beam scale (Detecto Scales, Brooklyn, NY). Body Mass Index was calculated by dividing mass by height squared ($kg/m^2$).

**Procedures**

Investigators came to the schools on an assigned day to administer the tests to the children who had the appropriate forms completed for participation. Each subject completed a packet including the Youth Health Survey and Eating Habits Questionnaire. Later that day or the following day, the subjects returned to complete height and weight measurements. Subjects wore shorts and shirt but no shoes. Height was recorded to nearest 0.1 cm, and body mass was recorded to nearest 0.1 kg.

**Determination of Scores**

PA scores were determined by multiplying an activity's MET value by the number of times the child participated in the activity per week (Ainsworth et al., 1993). The physical activity change scores ($\Delta PA$) were obtained by subtracting the first year's PA from the last year's PA.

SB scores were the number of sugar-sweetened drinks per day. If the answer was
a range (i.e. one to three) per week, the score was the range's average divided by seven (i.e. 1.5/7) to yield the daily average. Change scores (ΔSB) were determined by subtracting the SB for the first year from the SB in the last year.

BMI percentile was found by comparing the children's BMI scores to an age-appropriate BMI percentile chart (CDC, 2000). The change score for BMI percentile (ΔBMI%) was found by subtracting the BMI percentile of the first year from the BMI percentile of the last year.

**Statistical Analysis**

This study is between elementary and transition groups with a repeated measures design over a two-year period. All statistical analyses were completed with SAS statistical software (Cary, NC). Means ± standard deviations were found for all variables, and change scores were computed for BMI%, SB, and PA by group. Pearson correlations were used to determine the association between changes in BMI percentile, SB, and PA.

RQ1 addresses children's BMI percentile changing over time in relation to ΔSB. Multiple regression analysis examined the association between changes in BMI percentile and SB changes after accounting for sex and race. The equation is as follows:

\[ \Delta \text{BMI}\% = \Delta \text{SB} (+ \text{sex} + \text{race}) \]

RQ2 adds ΔPA to the multiple regression model, which produces the following equation:

\[ \Delta \text{BMI}\% = \Delta \text{SB} + \Delta \text{PA} (+ \text{sex} + \text{race}) \]

RQ3 looks at the variables ΔBMI%, ΔSB, and ΔPA independently between elementary and transition groups. Independent t-tests between the elementary and transition groups were run to determine significance between each of those variables. Assuming
significance ($p<0.05$), RQ4 uses multiple regression analyses by groups to examine the proportional differences in $\Delta SB$ and $\Delta PA$. 
CHAPTER IV

Results

Subject Characteristics

Table 1. Means ± standard deviations for physical characteristics and physical activity in the elementary and transition groups in the first (T₁) and final (T₂) years of study overall and by race (AA= African American, Cauc= Caucasian), * = p<0.0001 between groups.

<table>
<thead>
<tr>
<th></th>
<th>Elementary</th>
<th></th>
<th>Transition</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T₁</td>
<td>T₂</td>
<td>T₁</td>
<td>T₂</td>
</tr>
<tr>
<td><strong>Height (cm)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA</td>
<td>134.0 ± 8.1</td>
<td>144.9 ± 8.0</td>
<td>147 ± 7.4</td>
<td>158.1 ± 7.3</td>
</tr>
<tr>
<td>Cauc</td>
<td>135.7 ± 8.3</td>
<td>146.8 ± 8.2</td>
<td>149.1 ± 6.5</td>
<td>159.0 ± 6.2</td>
</tr>
<tr>
<td><strong>Mass (kg)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA</td>
<td>36.0 ± 12.5</td>
<td>46.1 ± 15.5</td>
<td>49.1 ± 15.3</td>
<td>60.9 ± 18.1</td>
</tr>
<tr>
<td>Cauc</td>
<td>38.0 ± 12.8</td>
<td>49.3 ± 15.3</td>
<td>56.9 ± 15.7</td>
<td>69.6 ± 18.2</td>
</tr>
<tr>
<td><strong>BMI (kg/m²)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA</td>
<td>19.8 ± 5.4</td>
<td>21.7 ± 6.2</td>
<td>22.5 ± 5.7</td>
<td>24.2 ± 6.3</td>
</tr>
<tr>
<td>Cauc</td>
<td>20.5 ± 6.0</td>
<td>22.9 ± 6.9</td>
<td>25.3 ± 5.8</td>
<td>27.4 ± 6.5</td>
</tr>
<tr>
<td><strong>BMI %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA</td>
<td>69.6 ± 28.3</td>
<td>70.2 ± 29.8</td>
<td>74.7 ± 31.8</td>
<td>75.4 ± 31.7</td>
</tr>
<tr>
<td>Cauc</td>
<td>74.3 ± 24.0</td>
<td>75.4 ± 26.4</td>
<td>86.0 ± 26.0</td>
<td>88.3 ± 22.3</td>
</tr>
<tr>
<td><strong>PA (PA28 score)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA</td>
<td>390.7 ± 112.6</td>
<td>406.2 ± 92.6*</td>
<td>393.2 ± 100.2</td>
<td>228.5 ± 122.2*</td>
</tr>
<tr>
<td>Cauc</td>
<td>394.6 ± 133.1</td>
<td>398.7 ± 98.2</td>
<td>406.9 ± 104.4</td>
<td>235.2 ± 135.0</td>
</tr>
<tr>
<td></td>
<td>386.8 ± 90.1</td>
<td>413.8 ± 88.1</td>
<td>380.5 ± 96.5</td>
<td>222.3 ± 111.5</td>
</tr>
</tbody>
</table>

This study involved 100 subjects; 50 in the elementary group and 50 in the
transition group. The means and standard deviations of physical characteristics for each
group are shown in Table 1. The elementary group was evenly divided by sex and race
(African-American or Caucasian). The transition group consisted of 24 males and 26
females and had 24 African-American (AA) students and 26 Caucasian students. In the
first year of the study ($T_1$), the mean age in the elementary group was $8.5 \pm 0.8$ years old,
and the mean age of the transition group was $10.4 \pm 0.7$ years old.

The BMI percentiles for AA children were significantly higher than their
Caucasian counterparts ($p<0.005$). Although PA was not significantly different between
groups for the first year ($T_1$), the transition group was significantly less active than the
elementary group in the final year ($T_2$) of the study ($p<0.0001$).

The means for all variables in Table 1 were similar between the elementary and
transition groups in the fifth grade year (elementary $T_2$, transition $T_1$). Therefore, the
similarities in fifth grade show that the any changes between groups in the final year of
the study is not due to a pre-existing difference between groups but might be associated
with a change in school environment.

**Sweetened Beverage Consumption at $T_1$ and $T_2$**

On the Eating Habits Questionnaire, students reported how many drinks they
consumed during the previous week in each of four categories. Table 2 lists the students'
responses. Regular soda consumption did not increase from $T_1$ to $T_2$ for either the
elementary or transition group; however, the transition group had greater consumption of
regular soda overall. Although fruit soda generally dropped over the two years for both
the elementary and transition groups, the transition group had a large increase in the proportion consuming 7+ servings per week. The same phenomenon also occurred in the punch category for the transition group. Juice consumption decreased overall from $T_1$ to $T_2$ for both groups.

Table 2. Number of students who reported sweetened-beverage consumption (drinks/week) by individual drink category. Elem = elementary group; Trans = Transition group; $T_1$ = first year; $T_2$ = last year.

<table>
<thead>
<tr>
<th>Sweetened Beverage</th>
<th>Servings per Week</th>
<th>0</th>
<th>1-2</th>
<th>3-5</th>
<th>6</th>
<th>7+</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regular soda</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elem $T_1$</td>
<td>8</td>
<td>6</td>
<td>18</td>
<td>9</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Elem $T_2$</td>
<td>2</td>
<td>14</td>
<td>13</td>
<td>16</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Trans $T_1$</td>
<td>5</td>
<td>9</td>
<td>16</td>
<td>8</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Trans $T_2$</td>
<td>6</td>
<td>12</td>
<td>11</td>
<td>4</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td><strong>Fruit Soda</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elem $T_1$</td>
<td>8</td>
<td>6</td>
<td>19</td>
<td>10</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Elem $T_2$</td>
<td>12</td>
<td>15</td>
<td>15</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Trans $T_1$</td>
<td>10</td>
<td>14</td>
<td>15</td>
<td>8</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Trans $T_2$</td>
<td>15</td>
<td>13</td>
<td>8</td>
<td>3</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td><strong>Punch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elem $T_1$</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Elem $T_2$</td>
<td>13</td>
<td>7</td>
<td>13</td>
<td>11</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Trans $T_1$</td>
<td>10</td>
<td>9</td>
<td>10</td>
<td>13</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Trans $T_2$</td>
<td>16</td>
<td>8</td>
<td>7</td>
<td>3</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td><strong>Fruit juice</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elem $T_1$</td>
<td>13</td>
<td>5</td>
<td>12</td>
<td>8</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Elem $T_2$</td>
<td>6</td>
<td>15</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Trans $T_1$</td>
<td>11</td>
<td>8</td>
<td>14</td>
<td>8</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Trans $T_2$</td>
<td>25</td>
<td>6</td>
<td>10</td>
<td>3</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>
The responses within each subcategory are graphed in Figure 1. In general, the proportion of elementary group students in higher frequency categories decreased. The transition group experienced some decreases in the middle region but had several students move to the upper end of the scale, indicating more frequent consumption. Examination of students' individual $T_1$ versus $T_2$ consumption indicates the majority of the students did not drastically alter their beverage behavior.

Figure 1. Percentage of students in each group reporting frequency of sugar-sweetened beverage consumption in the elementary (E) or transition (Tr) group in the first year ($T_1$) or last year ($T_2$).

The means of total SB consumption in each group are shown in Table 3. Independent t-test analyses between the elementary and transition groups show overall SB consumption was not different at $T_1$ or $T_2$. ANOVAs within the elementary and the transition group for SB consumption were run for sex and race. Sex differences in SB
consumption were not found (p>0.05), and no interaction effect for sex and race was found in either group. However, racial differences were significant as an overall main effect (p<0.05). Although the elementary group all decreased consumption from T₁ to T₂, the Caucasians drank less in the fifth grade than their AA counterparts (p<0.01). In the transition group, Caucasians also drank less SB than the AA in the fifth grade year (p<0.01). SB consumption increased for both races in the transition group, and in the final year, AA children in the transition group drank slightly more than the Caucasian children (p<0.01).

Table 3. Means and standard deviations for sweetened-beverage consumption (drinks/day) by sex and race within the elementary or transition group. Significant results are indicated by (**)=p<0.01 and (*) = p<0.10 for racial comparisons within groups.

<table>
<thead>
<tr>
<th></th>
<th>Elementary</th>
<th>Transition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T₁</td>
<td>T₂</td>
</tr>
<tr>
<td>Total</td>
<td>2.50 ± 1.18</td>
<td>2.12 ± 1.19</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2.73 ± 1.10</td>
<td>2.18 ± 1.11</td>
</tr>
<tr>
<td>Female</td>
<td>2.27 ± 1.24</td>
<td>2.08 ± 1.29</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>African-American</td>
<td>2.65 ± 1.43</td>
<td>2.57 ± 1.29**</td>
</tr>
<tr>
<td>Caucasian</td>
<td>2.34 ± 0.86</td>
<td>1.69 ± 0.91**</td>
</tr>
</tbody>
</table>

Overall Changes in BMI percentile, consumption, and physical activity

The means and standard deviations for the change scores (Δ) from T₁ to T₂ are shown in Table 4. Results suggest that the elementary group decreased SB and increased PA whereas the transition group was the reverse. Repeated ANOVA results for ΔSB
only yielded a trend in the elementary group to decrease consumption (p<0.10) compared to the transition group. Despite a significant drop in PA for the transition group (p<0.001), the ΔBMI% were similar for the elementary and transition groups. Regardless of group, 54% of the students increased BMI% over the two year period in this study. The distribution of students who increased BMI% versus those who fell or maintained the same BMI% was examined, a posteriori. Chi-Square tests confirmed that the distribution of scores between groups was not different, with 52% of the elementary group and 56% of the transition group having increased BMI%.

Table 4. Means ± standard deviations for changes (Δ=T₂-T₁) in BMI%, sugar-sweetened beverage (SB) consumption, and physical activity scores (PA) over the two-year period. T-test results between groups: **= p<0.01, *= p<0.10.

<table>
<thead>
<tr>
<th></th>
<th>Elementary</th>
<th>Transition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ BMI%</td>
<td>0.6 ± 10.3</td>
<td>0.7 ± 9.40</td>
</tr>
<tr>
<td>Δ SB</td>
<td>-0.37 ± 1.50*</td>
<td>0.02 ± 1.7*</td>
</tr>
<tr>
<td>Δ PA</td>
<td>15.5 ± 121.2**</td>
<td>-164.6 ± 125.6**</td>
</tr>
</tbody>
</table>

To explore the trend in ΔSB, the means and standard deviations of consumption changes (Δ) for each of the four drink categories were computed by group. In all categories, the elementary group generally decreased consumption, but the transition group generally increased consumption. The only drink categories yielding significant results for Δ consumption between groups were fruit sodas (elem= -0.17 ± 0.59 drinks/day, trans= 0.09 ± 0.61 drinks/day; p<0.05) and punches (elem= -0.16 ± 0.59 drinks/day, trans= 0.10 ± 0.71 drinks/day; p<0.05). When grouping the students according to increased BMI% (INC) versus no increase in BMI% (NC) from T₁ to T₂, the only significant t-test
results were in Δ fruit juice (INC= -0.24 ± 0.55 drinks/day, NC= 0.03 ± 0.71, p=0.03). No significant results were found when comparing INC and NC within the elementary or transition groups.

Multiple Regression Models

The relationship between ΔBMI%, ΔSB, and ΔPA was first examined using bivariate Pearson correlations computed within groups. Only the elementary group's ΔBMI% and ΔPA had significant relationship (R²=0.075, p=0.05). All other relationships in elementary, transition, or overall groups were not significant. Since none of the correlations were significant in the transition group, no multiple regression analyses were completed. In the elementary group, the relationships were then tested using a multivariate step-wise regression model. ΔBMI% was the dependent variable. After accounting for gender, mother's education, and race, ΔPA was the only independent variable influencing ΔBMI% ( R²=0.114, p=0.031).
CHAPTER V

Discussion

The purpose of this study was to determine if the transition from an elementary to a middle school environment has an impact on the relationship between changes in sugar-sweetened (SB) beverage consumption, physical activity, and weight status. Consumption of SB, physical activity levels and BMI percentiles were evaluated over two years in children who remained in elementary school and children who transitioned from an elementary to middle school environment. In general, this study found that, despite a significant drop in physical activity when transitioning into middle school, no relationship exists between changes in SB consumption and BMI% over the two-year period. The following discussion will explore the results pertaining to SB, PA, and BMI% including past research, the limitations faced in the process, and recommendations for future studies.

Sugar-sweetened Beverage Consumption

The overall SB consumption in this sample was higher than expected based on the literature. The mean daily consumption at T1 in this study's sample was 2.50 drinks/day for elementary children and 2.26 drinks/day for the transition group. Blum and colleagues (2005) found a much lower initial mean for daily SB consumption, less than one serving per day (7.4 ± 9.3 oz/d). Striegel-Moore and colleagues (2006) reported
initial mean SB consumption of approximately one to 1.5 servings per day (Caucasian girls: 10.97 fl oz/d, African-American girls: 12.77 fl oz/d). Although SB consumption in previous literature was lower than the current study's sample, similarities are found in the trends for consumption over time. Subjects in the present study exhibited no significant change in SB consumption over time in either the elementary or transition groups. Blum et al. (2005) also found no significant change in overall consumption over the two-year period for any BMI Z-score group. Comparing the present study's results to Striegel-Moore and colleagues (2006), both studies show regular soda consumption starting at approximately ½ serving per day. Table 2 shows the majority of consumption frequency for regular soda in the first year at “3-5 drinks per week” or about ½ serving per day. Striegel-Moore and colleagues (2006) reported increases in regular soda (g/d) that were nearly linear over a ten-year period (Caucasian girls: 135.45 g/d to 377.02 g/d; African-American girls: 134.53 g/d to 338.48 g/d). Examination of individual data from the present study reveals that regular soda contributed to the overall SB consumption increases for most students who drank more SB consumption in the last year. This apparent trend for individual increases in the regular soda category is worthy of note, despite no statistical difference between groups, because numerous studies have found a link between regular soda and weight status (Ludwig et al., 2001; Phillips et al., 2004; Striegel-Moore et al., 2006).

The general trends in frequency of consumption from T<sub>1</sub> to T<sub>2</sub> suggest that some drink choices increase while others decrease, possibly preventing an overall significant result in one direction. In Table 2, subjects in both groups tended to drink similar levels
of regular soda but consumed fruit juice less often by $T_2$. This trend could indicate a decline in healthy beverage choices, but it did not emerge in statistical analyses. Results might also be confounded by unexplained polarizing in the fruit soda and punch categories (see Table 2). The means for the number of students consuming fruit soda or punch do not depict the trend to drinking either much less or much more fruit soda or punch from $T_1$ to $T_2$.

Changes in Sugar-sweetened Beverage Consumption and Changes in BMI Percentile

The first research question addressed changes in SB associated with changes in BMI% with a hypothesis that SB consumption would increase along with BMI%. However, neither the elementary or transition groups exhibited significant changes in BMI% or SB from baseline to year two.

When the subjects were divided by weight status rather than school group, the only significant finding was a decrease in juice consumption for those whose BMI% increased. The link could perhaps lie in the other food choices that accompany juice consumption. Fruit juice, fruit, and vegetable consumption are significantly correlated to the availability at home (Cullen et al., 2003). If a parent stocks 100% fruit juice, a more nutritious and natural selection in comparison to juices with high-fructose corn syrup, then other foods that they provide might also be more nutritious. Perhaps the subjects in this study who increased BMI% and decreased juice consumption might have other food choices that would be less nutritious. Although regular soda consumption did not significantly change (see Table 2), the average number of drinks/day is relatively high compared to past literature. Soda consumption has been shown to be not only a beverage
choice but also an indicator that other dietary choices are higher in sugar, fat, or sodium (Tuorila et al., 1990). These other foods could be contributing to the increase in BMI%.

Physical Activity

This study concurs with past research showing that physical activity levels decline as students age (Gordon-Larsen et al., 2000). The elementary group did not alter PA much; however, the pronounced drop in the transition group suggests that the move to middle school highly impacted their activity level. This corresponds to similar results found by Trost et al. (2002), who reported that the largest difference in PA among four grade groups was between “Grades 1-3” and “Grades 4-6.” A shift to competitive, selective, team-based activity in middle school could prevent a large portion of children from participating. Increasing independence and a shift to peer influence (Steinberg & Silverberg, 1986) could also contribute to falling PA if the chosen activities are more sedentary. The highly significant difference in change of PA between groups suggests that the transition period from fifth grade to seventh grade is a crucial time during which to combat decline in PA. It seems this is one of few studies to make that distinction.

Changes in Physical Activity and Changes in BMI Percentile

Multiple regression analysis revealed that change in PA was a significant independent variable associated with change in BMI% in the elementary group (p=0.05). Recent studies also support the finding that low PA or increased sedentary activities, such as television watching, are significant determinants for children being at risk of overweight or overweight (Berkey et al., 2000; Crespo et al., 2001; Giammattei et al.,
Because children who are inactive or decrease activity levels tend to gain weight over time (Kimm et al., 2005), parents and those working with children should strive to encourage high activity levels to maintain a healthy weight.

Role of Physical Activity with Beverage Consumption and Weight Status

The second research question investigated whether PA would have an impact on moderating the relationship between the change in SB and the change in BMI%. This research question is built on the prediction that SB and BMI% undergo changes that are similar and significantly related. However, the subjects did not alter SB consumption and BMI% did not change drastically. Consequently, simple correlations between change in SB and the change in BMI% were not significant, and multivariate analysis with PA was not necessary.

The question about the relationship amongst the three variables therefore becomes, why did the transition group's dramatic decline in PA not lead to a larger increase in BMI% relative to the elementary group, especially since SB remained unchanged? Other factors must be responsible for the phenomenon where PA drops, SB remains unchanged, but BMI% is similar for the elementary and transition groups. One possible explanation is the decreasing protein needs. Analysis of nitrogen (N) indicates amino acid and protein use in the body. When the body is in positive nitrogen balance, the dietary input of protein is providing enough nitrogen to synthesize lean tissue and store amino acids (Brooks et al., 2005). Children's protein requirements (g/kg) lessen as they age because the body is undergoing much less growth than in earlier stages. For
example, six year old children require approximately 9 mg N/kg/day whereas 12 year old children only need 6 mg N/kg/day (Tontisirin, 2002). Perhaps the decline in caloric expenditure via PA is balanced by the body's natural decrease in protein needs. Alternatively, the 7th grade adolescent needs more absolute kcal to sustain resting metabolic rate than the 5th grade adolescent. Although the absolute need is greater, weight could be maintained by simply reducing physical activity (kcal output) while not changing diet (kcal input).

Impact of School Environment on Consumption, Physical Activity, and Weight Status

The third research question examined the impact of a change in school environment on SB, PA, or BMI%. Past research has shown that more sodas are available in middle and high schools than in elementary school (Fried & Nestle, 2002). At the same time, children become more sedentary with increasing age (Aaron et al., 2002; Brodersen et al., 2007). Because more children are becoming obese at younger ages relative to past decades (CDC, 1999), it is necessary to examine where changes could be made to counteract these trends.

This study anticipated that the transition group would increase SB consumption in middle school, whereas the elementary SB consumption would not change significantly. However, results show that the transition group did not change SB consumption significantly. Figure 1 reveals similarities in the elementary school years, shown by the first three bars in each grouping. Both groups exhibit similar SB behavior in fifth grade, shown by the likeness between the middle bars. The fourth bar (TrT2) in each grouping indicates the middle school influences, and large changes are evident. Figure 1 shows a
large increase in the middle school year for the number of children consuming “31.5 and above” drinks per week. A subsequent drop in the proportion of participants in the “10.5 - 20.9” drinks per week category also occurs. Students in middle school are shifting away from the middle range of SB consumption, suggesting outside factors that either decrease or rapidly increase consumption. Schools and parents should work to prevent significant consumption changes into high levels when children move to middle school. With the number of pouring rights contracts in schools increasing every year (Fried & Nestle, 2002), measures should be put in place to avoid SB increases from becoming unmanageable.

The present study's results for the transition group show no change in SB but a significant drop in physical activity. As previously discussed, this study shows the transition period from fifth to seventh grade is a crucial period to focus efforts to maintain PA. Aaron et al. (2002) found that if an adolescent participates in an activity from middle through high school, the amount of time spent on that activity will stay constant or increase. Results for the middle school students in the current study demonstrate that more PA needs to be initiated at this stage in order to encourage later participation into the high school years. Beverage availability and participation in physical activities are two areas that deserve attention for countering the growing number of obese children.

Ethnicity and Sugar-sweetened Beverage Consumption

A departure from past research is the racial differences for SB consumption within groups (see Table 3). Independent t-tests between race in each group found African-
American fifth grade students drank significantly more SB per day than their Caucasian counterparts (elementary group T₂: 2.57 ± 1.29, 1.69 ± 0.91, respectively; transition group T₁: 2.66 ± 1.05, 1.89 ± 0.89, respectively). However, that difference is not present in the third grade (elementary group T₁) and is only a trend in the seventh grade (transition group T₃, p<0.10). In contrast to these findings, Forshee and Storey (2003) found that African-Americans drank less of any beverage compared to their Caucasian counterparts. The present study found an approximately half-drink per day difference between the two races. A half-drink difference might not seem clinically relevant at first glance. However, a half-can of regular soda per day would equate to an increase of 75 kcal/d, which is an extra pound of weight in 48 days. ANOVA results for BMI% by group and race found a main effect for race. The AA students were consistently heavier than the Caucasian students. Perhaps in this population, higher SB consumption is contributing to the weight differences between races.

Strengths and Limitations

A few limitations may have contributed to the lack of significant relationships between changes in SB, changes in PA, and changes in BMI% between groups. Because the study is retrospective, some limitations could not be avoided (discussed below), but random samples, longitudinal data allowing repeated measures for all subjects, and precautions in testing help increase the power of the study.

Data collected for both SB and PA relied on questionnaires completed by the subjects in small groups. Although answers were self-reported due to constraints on time and funding, the instruments were validated and administered by trained assistants who
used scripted instructions and offered the children opportunities to ask questions. Standardizing this procedure helped ensure that the self-reported answers were as reliable as possible. The versions of the questionnaire were slightly different for elementary and middle school in order to be age-appropriate. In making the versions age-appropriate, the number of answer possibilities differed (elementary: six frequency categories per week, middle: seven frequency categories per week). For statistical purposes and to compare means, frequency categories were merged. In both versions, “not last week” and “never drink it” answers were coded as zero. To bring the middle school version categories down to an equal level with the elementary version, “3 or more times a day” and “1 to 2 times a day” were also chosen to be merged since the highest frequency on the elementary version was “every day.” The merges were selected to have the least impact on statistical results.

The other limitation concerning SB was quantifying SB by frequency of consumption, not serving size, due to the design of the questionnaire. The students' perceptions about serving size could affect their answers on the EHQ. A medium size drink at McDonald's is 21 fluid ounces, but the official serving size of a drink is 8 fluid ounces. Some students might consider that McDonald's beverage as one drink when the answer should truly be almost three. Drinks also have different sizes for typical dispensing, such as 12-ounce cans of fruit juice or 20-ounce bottles of soda. Calories per serving also differs between types of drinks, such as Gatorade (50 calories/8-oz serving) or Coca-Cola Classic (97 calories/8-oz serving). Despite the caloric intake questions, the results in Figure 1 suggest that more children are consuming more SB, which regardless
of the energy value, has poor implications for the children's health.

The method to measure PA in the Youth Health Survey (YHS) asks about activities in the last week, which is easier to comprehend for a student. This study examines data that covered a two-year period. Despite seasonal activities possibly being under- or overrepresented in the YHS, the data was collected at the same time each year, which is a consistency that enhances repeated measures. In relation to this study’s examination of school environment, the YHS does not account for where the activity occurred. It is not clear if the activities are directly related to school activities or were extracurricular activities.

Finally, information on drink policies and PA requirements in the schools that were involved in this study was not available. It is known that all the schools are involved in pouring rights contracts. The prevalence and use of the machines in these particular locations is not known. As for PA, the specific requirements by the schools is not given or specified on the questionnaire, so participation in school versus self-selected extracurricular activities is uncertain. These unknowns should not statistically harm the findings.

Despite these limitations caused by the retrospective constraints, this study is the first to explore changes in SB, PA, and BMI% between changing school environments. Hopefully this will encourage more research to compare age groups and environment in respect to children and weight gain.

**Conclusions**

Based on the results of this study, the following hypotheses were either accepted
or rejected. Hypothesis one predicted that change in SB will be positively associated with change in BMI%. There were no significant changes in SB consumption or BMI percentile, and bivariate Pearson correlations for these factors were not significant (p > 0.05); therefore, the hypothesis is not accepted. Hypothesis two stated that the shift in school environment into middle school will cause larger increases in SB consumption, decreases in PA, and a greater rate of obesity than in elementary school children. A highly significant decline in PA was found in the transition group as compared to no change in the elementary group. However, ΔSB and ΔBMI% were not significant between groups. Therefore, only a part of the hypothesis can be accepted: shifting to middle school will cause a decrease in PA. The other two statements in the hypothesis pertaining to ΔSB and ΔBMI% are not accepted. This study agrees with past literature that PA declines as children get older, adding that the shift to middle school is a critical time when the drop in PA occurs. However, SB consumption in the elementary and middle school groups does not differ and does not relate to BMI%.

Recommendations

An important finding of this research is that PA levels for children moving into middle school undergo an astounding decline, highlighting a need for intervention in this period. Although this study did not show corresponding increases in BMI% with those changes, limitations could be preventing the emergence of a truly significant relationship with SB, PA, and BMI%. Therefore, the value of the results should not be discounted but rather spur further research that increases the power to identify relationships.

To improve future study in the relationships of SB, PA, and weight status amongst
school-age children, more accurate measures of calories consumed and expended are necessary. SB consumption would ideally quantify serving size, which can then be used to obtain kilocalories. A modified approach to this study could isolate the SB categories and sort by caloric value, such as separating sports drinks from punches.

Some unexpected findings in this study suggest needed exploration into race relationships with SB during elementary and middle school years. It is unclear why a rise in SB consumption by African-American students would occur in the fifth grade population. The race relationship in individual drink categories, such as regular soda versus fruit juice, might be of interest in light of the results showing those who gained weight decreased juice consumption.

Research with a control and intervention groups concerning SB and PA for students moving into middle school would also improve the design of studies. Whereas the present study was observational, conducting a true experimental study would possibly allow more definitive results. The intervention groups would involve sustaining energy expenditure and decreasing SB. Ebbeling et al.’s pilot study (2006) showed that an intervention decreasing SB consumption had a beneficial effect of reducing weight status for the children in the upper tertile of baseline-BMI. The proposed recommendation would modify this approach to include another intervention group that would also sustain baseline physical activity, since this study shows it drops significantly when aging into middle school.

Exploration of trends in these school-age years would be valuable in focusing public policy and measures to prevent childhood obesity. Considering the tendency for
obesity to track into adulthood (Serdula et al., 1993; Yang et al., 2006) and that lifetime habits and views form in these critical years (Carter, 2002), it is crucial to gain further understanding of what factors most contribute to childhood weight gain.
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