Changes in BMI Between Summer and School Months Among Middle School Students

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Purpose: This study sought to compare changes in body mass index between summer months and fall term school months among middle school students in the U.S. Pacific Northwest. Further, this study was designed to detect differences in changes in body mass index based on gender, body mass index percentile classification, school grade and participation in the free/reduced lunch program.
Method: The study included 865 early adolescents with anthropometric measurements at baseline in the spring 2007, at T1 (start of fall term 2007) and at T2 (end of fall Term 2007). Changes in BMI Ratio, an index of the percent above or below ideal BMI (for age in months and gender), were tracked longitudinally.
Results: The study found significant decreases in BMI Ratio for middle school subjects during summer months compared to an equal interval of time during fall term of the academic school year.
Conclusion: This study suggests that the summer months may contribute to improved weight in early adolescents. Further examination of changes in seasonal weight status of early adolescents is warranted.

Introduction and Review of Literature

Overweight and obesity pose significant health problems for adolescents. Approximately 17% of U.S. adolescents are overweight, and another 16% are considered at risk of becoming overweight (Ogden, 2006). Rates of overweight in adolescence have increased three-fold since 1980 (Centers for Disease Control and Prevention). The consequences of adolescent obesity are well-known, including increased risk for numerous medical conditions, dysfunctional eating behaviors, and impaired social/emotional development (Williams, 2005).

Healthy People 2010/2020 provide a public health prevention framework by determining top priorities for the nation's health. Reduction in the proportion of children and adolescents who are overweight or obese is an important adolescent critical health objective (U.S. Department of Health and Human Services, 2000). It is unclear if public health prevention efforts to improve children and adolescent weight status should be school-based or community-based. While some have argued for school-based prevention programs (Probart, 2007, Peterson, 2007), others have contended that such programs have limited success and that family- or community-based programs are necessary (Stice, 2006, Thomas, 2006).

These differences in opinion are based partially on the factors thought to contribute to adolescent obesity. If, for example, obesity is primarily a consequence of obesogenic school environments (Carter, 2002, Nader 2003) (e.g., high calorie school lunches, excessive sedentary behavior), then programs that modify school environments should be implemented. If, on the other hand, obesity is primarily a consequence of factors outside of the schools (Brownwell 2004, Gable, 2007) (e.g., fast-food consumption, excessive screen time), then community- or family-based interventions should be most effective. One way to examine the relative impact of in-school and out-of-school factors on the development of obesity is to compare changes in body mass index (BMI) during the school year to changes during summer months (von Hippel, 2007). While von Hippel's study included much younger children, such a study design provides a natural experiment providing data on the relative impact of school and non-school environments among early adolescents. Such an approach has been useful in documenting the effects of in-school and out-of-school environments in other domains such as changes in math and reading skills (Downey, 2007).

The evidence related to changes in childhood weight by season is not clear. Some studies have shown faster and more variable BMI growth during summer and loss of school-based improvements in physical fitness during the summer months (Carrel, 2007, Christodoulos, 2006). Other studies show obesity rates are lowest during the summer months (Johnson, 1956, Dietz, 1984). In a recent study conducted in Japan, most elementary school children showed weight decreases during the summer and weight gains during the school year. Children who were obese often demonstrated an exception showing weight gains during the summer (Kobayashi, 2006).

The current study examined seasonal variations in children's weight in a longitudinal study of middle school students in the U.S. Pacific Northwest. We expected changes in autonomy and increased decision making (Zimmer-Gembeck, 2003) for healthy eating and physical activity would result in differences in weight status throughout their middle school years. Moreover, we examined how changes in weight were moderated by gender and social class—factors associated with the prevalence of obesity in previous research (Johnson, 2007, Institute of Medicine, 2007) Finally, given the results of Kobayashi and Kobayashi, (2006) we also examined how these changes were moderated by children's baseline weight status. The study aims were to:

1. Compare changes in BMI during summer months to changes in BMI during fall term among middle school students.
2. Identify group differences based on gender, BMI percentile classification, school grade and participation in the free/reduced lunch program for changes in BMI among middle school students.
3. Examine which environment (school-based or community-based) is currently associated with changes (if any) in adolescent weight status.

Methods

Participants

Early adolescents enrolled in 6 public middle schools in the Pacific Northwest during the spring term of 2007 were eligible for this longitudinal study. Subjects without anthropometric measurements at all 3 points in the study and early adolescents with body mass index less than the 5th percentile were excluded. The study included 865 subjects. Personal identifiers were removed and a unique study-specific identification number was assigned to each participant by the school district. The key to match the unique study-specific identification number and the participant's identifying information was not available to investigators. More than 90% of students in this school district are Caucasian. To protect the identity of non-Caucasian student's race was not included in demographic information extracted for this study. Approval for the project was granted by the School Board. Based on the Exemption Determination Application submitted by study investigators, the Washington State University Institutional Review Board determined that the study satisfied the criteria for Exempt Research.

Measures of Weight Status

Height was measured on a standing stadiometer with shoes, hair ornaments, hats, jewelry and braids removed. Subjects were instructed to stand facing outward with feet together with heels, buttocks, shoulder blades and back of the head in contact with the vertical backboard. Subjects were instructed to look straight forward and to stand tall. The upper measure of the stadiometer was aligned and the subject stepped away. The height was measured and recorded in feet and inches with two decimal points as needed. Weight was measured on a Seca digital scale with shoes, coats and other heavy clothing removed. The readout was located so it was not be visible to anyone other than the person being weighed; weight was recorded in pounds with two decimal points as needed. BMI was calculated by dividing weight in pounds by height in inches squared and multiplying by a conversion factor of seven hundred three (Cole, 2005). The measure of weight status used in this study is the ratio of the subject's BMI to the subject's ideal BMI. Subjects' percent overweight or underweight is the indexed percent above or below the median BMI for children of the subject's age in months and gender. Because this percentage takes into account a child's age, gender, and height, as well as allowing for comparisons across time in individuals who are still developing, it is a preferred outcome variable for this population (Centers for Disease Control and Prevention. Healthy Weight - it's not a diet, it's a lifestyle!, Dietel, 2003, Levine, 2001). Hereafter, this measurement in the current study is called the BMI Ratio.

Measures of Socio Economic Status

In order to examine changes in weight status as a function of social class, socio economic status (SES) was determined by a dichotomous variable indicating participation or lack of participation in the school district's free and reduced lunch program. Although an imperfect marker, free and reduced lunch (FRL) program status has been used as an unobtrusive measure of SES (Johnson, 1956). In order to qualify for free or reduced prices for school-based meals, a student's parent completed an application. The student's enrollment in the FRL program at the beginning of the 2007-2008 academic year was used to assess the relationship of the free and reduced meal program with changes in the participant's weight status.

Statistical Analysis

To determine descriptive group differences among categorical variables, Pearson chi-square statistics were calculated. To determine descriptive group differences among continuous variables, independent samples t-test statistics were calculated. The multivariate approach to repeated measures (MANOVA) was used to compare changes in BMI Ratio during summer months to changes in BMI Ratio during enrollment in the fall term of middle school students. The between-subjects factors for this analysis yielded a 2 x 2 x 2 x 3 design (24 combinations of gender by grade by FRL status by BMI percentile classification - recommended weight, overweight, obese). The within-subjects factor, timepoint, had three levels. In order to identify group differences in patterns of BMI ratio over time as a function of gender, BMI percentile classification, school grade and FRL status paired samples t-tests were used for the highest order interaction. Significance was established as $\varrho < .01$ a priori.

Results

This study sought to compare changes in BMI during summer months to changes in BMI during the fall term among middle school students. Cohort A included sixth graders who were followed longitudinally until they became seventh graders. Cohort B included seventh graders who were followed longitudinally until they became eighth graders. Demographic and anthropometric measurements were compared for subjects in both cohorts (Table 1). Proportion of male and female subjects did not differ between the two cohorts ($\chi 2(1)=.433$; $\varrho>.05$). A higher proportion (χ $2(1)=15.585$; $\varrho<.001$) of subjects Cohort A (57.0%) participated in the free and reduced lunch program compared to Cohort B (42.8%). As expected, subjects in Cohort A were younger (t(863)=-33.919; $\varrho<.001$), weighed less (t (863)=-3.981; $\varrho<.001$) and were shorter (t(863) =-10.902; $\varrho<.001$) compared to subjects in Cohort B. No statistical differences in mean BMI or weight status classification (recommended weight, overweight and obese) between the two cohorts were observed (χ $2(2)=3.613$; $\varrho>.05$).

Subjects' BMI Ratios were measured at 3 time periods in the study, at equally spaced intervals (Table 2). Repeated measures MANOVA yielded significant differences in BMI ratio across time [Pillai's Trace=.153, F(2,863)=52.201; ϱ <.001, ηp2=.153]. Tests of within-subjects contrasts indicated statistical differences [F(1,864)=132.544; ϱ <.001, ηp2=.136] in the BMI Ratio between baseline (Spring 2007) and T1 (Start of Fall 2007). No statistical differences (F(1,864)=.860; $\varrho>.01$) were observed between T1 (Start of Fall 2007) and T2 (End of Fall 2007). That is, students evidenced a significant decrease in weight status during summer (baseline to T1) but no significant change in weight status occurred during school months (T1 to T2).

Repeated measures MANOVA with between-subjects factors for gender, school grade, FRL status and BMI percentile classification yielded gender [F(1,864)=7.986, ϱ =.005, ηp2=.009] and BMI percentile categorization [F(2,863)=689.345, ϱ <.001, ηp2=.621] as the only significant main effects. Estimates of marginal means for gender indicated girls (1.291) had a higher average BMI Ratio compared to boys (1.253) [ϱ =.005]. Estimates of marginal means for BMI percentile categorization and a Bonferonni pairwise comparison produced expected results. That is, mean BMI Ratio for students in the recommended weight BMI category was less than the mean BMI Ratio for students in the overweight category (ϱ<. 001). Mean BMI Ratio for students in the overweight category was less than the mean BMI Ratio for students in the obese category ($\varrho<.001$). There were no significant between-subject effects for grade and FRL status. Although a large number of interactions were significant, they were all qualified by the significant five-way interaction between gender, school grade, FRL status BMI percentile classification, and time [Pillai's Trace=.067, F(4,861)=1682.000; ϱ <.001, ηp2=.034]. Accordingly, changes in BMI Ratios over time for all group combinations of gender, school grade, FRL status and BMI percentile classification were compared using paired t-tests (table 3). Overall, mean BMI Ratio improved from baseline to T1 [t(864)=9.585; ϱ <.001]. Of the 24 combinations of gender, school grade, FRL status and BMI percentile classification, 8 groups experienced statistically significant changes in BMI Ratio from baseline to T1 (Table 3). Overall, mean BMI Ratio did not change from T1 to T2 [t (864)=.889; ϱ >.01]. Of the 24 combinations of gender, school grade, FRL status and BMI percentile classification, two groups experienced statistically significant changes in BMI Ratio from T1 to T2 (Table 3).

Discussion

This study compared changes in BMI adjusted for ideal BMI (BMI Ratio) during summer months to BMI Ratio during the fall term among middle school students. The major finding in this study is a signficiant change in BMI Ratio for middle school subjects during summer months compared to an equal interval of time during fall term of the school year.

Schools have been implicated in contributions to the obesity epidemic by offering high sugar drinks in vending machines, unhealthy foods in lunches and breakfasts, and scant opportunity for physical activity. However, a focus on schools as a setting for several hours daily for children from 9-10 months annually has resulted in recommendations for health programs in schools and strategies to improve the school environment. It is recommended that schools provide a consistent environment conducive to healthful eating and regular physical activity, through a series of standards promoted by federal, state, and local authorities (Institute of Medicine, 2007). It is probable that individual schools have instituted significant programs to improve youth health. Several school-based obesity prevention studies suggest that school-based programs are effective in reducing BMI in youth (Institute of Medicine, 2007). In fact, the school system in the urban location described in this article has a physical fitness curriculum with testing and goal setting for all middle school students, and has improved the general nutritional offerings with fruit and vegetable bars and other nutritional improvements. Our study findings do not confirm those of von Hippel et al who found that growth of kindergarten to first grade children was greater in the summer than in the school year (von Hippel, 2007). These findings do not negate the benefit of policy and classroom standards for obesity prevention. Such strategies should continue to be viewed an essential part of overall youth health programs, but more research is needed to understand changes in weight status during the transition from elementary school to middle school years.

An interesting finding of this study is that there were greater changes in BMI Ratio in students progressing from sixth to seventh grades (Cohort A) than in those progressing from seventh to eighth grades (Cohort B). This occurred for both genders, for youth with free and reduced lunch vs. paid lunch, and with youth of recommended vs. overweight status. In fact, there were no significant changes in Cohort B at any time period except for the sub-group of eighth grade girls during fall semester. This may reflect that the elementary to middle school years transition reflects variation among individuals due to developmental status, with heightened variability in growth patterns. It may also reflect the activity levels of youth of this age, who maintain patterns common during elementary years. Older youth, such as those advancing to eighth grade are perhaps more sedentary and have less improvement in BMI ratio in summer months, since decline in activity is associated with increase in BMI (Cole, 2005).

A number of limitations should be considered when interpreting the results of the current study. First, the present investigation examined changes in weight in isolation from other potentially relevant variables. The addition of variables that may have impacted the participant's weight status over time (e.g., parent weight change, participation in sports, etc.) will aid in the translation of these findings into effective treatment and prevention strategies for this population. Second, although change in BMI Ratio is certainly a robust measure of outcomes for this population, additional clinical indicators of health would only strengthen the research in this area. For example, including additional measures of central adiposity (e.g., triceps skinfold thickness, waist-to-hip ratio) and cardiovascular health (e.g., blood pressure, serum cholesterol) would enhance our understanding of how the health of preadolescents is being impacted by increases or decreases in weight. Finally, another important limitation relates to the lack of ethnic and racial diversity in the current sample. To increase the generalizability of the findings from the present investigation, it will be important to replicate results among a more diverse sample of students.

This study suggests that the summer months may contribute to healthy weight in youth transitioning from elementary school to middle school years, but plays little part in the transition from seventh to eight grades within the established middle school years. Larger cohort studies are needed to determine the differences that exist in growth and activity levels during the years of developmental change from school age to pre-pubertal to pubertal status. The relative impact of school and summer environments on these effects should be studied. This study was performed in an urban school district in the inland northwest, an area known for sports, physical fitness, and summer outdoor activities. Such an environment may encourage summer activity and healthful eating among youth. The variability in larger urban settings and rural areas should be contrasted with these results.

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Table 1. Demographics and Anthropometric Measurements by Cohort

Factor	Cohort A (n=582)	Cohort B (n=283)
% Female	46.7%	49.1%
% Free/Reduced Lunch **	57.0%	42.8%
Mean Age Months ** (std dev)	147.00 (4.601)	159.63 (6.089)
Mean Weight Pounds ** (std dev)	114.77 (32.15)	124.33 (35.07)
Mean Height Inches ** (std dev)	60.92 (3.29)	63.52 (3.28)
Mean Baseline BMI (std dev)	21.54 (4.91)	21.51 (5.27)
% Recommended Weight	57.9%	64.0%
% Overweight	21.0%	19.8%
% Obese	21.1%	16.3%

Notes: Cohort A represents students enrolled at the end of sixth grade and followed through the end of fall term in their seventh grade year. Cohort B represents students enrolled at the end of seventh grade and followed through the end of fall term in their eighth grade year.
** ϱ < .01

Table 2. Measurement of BMI Ratio over Time

Measure of BMI Ratio	Measure of BMI Ratio	Mean BMI Ratio (SD)	Mean BMI Ratio (SD)	ϱ value
Baseline (Spring 2007)	T1 (Start Fall 2007)	1.174 (.273)	1.148 (.275)	<.001
T1 (Start Fall 2007)	T2 (End Fall 2007)	1.148 (.275)	1.146 (.270)	.374 (NS)

BMI Ratio = (Research Subjects Measured BMI)/(Ideal BMI (50th Percentile BMI for Age (months) and Gender)

Table 3. Group Interactions in the Multivariate Model of Repeated Measures (MANOVA), (ϱ<.01)

Grade	**Gender**	**Lunch Status**	**BMI Percentile Classification**	**n**	**Baseline**	**T1**	**t**	**ϱ value**
7th	Boys	Paid	Recommended	102	1.01	.97	8.650	<.001
			Obese	28	1.57	1.52	3.198	.004
		FRL	Recommended	86	1.01	.96	7.474	<.001
	Girls	Paid	Recommended	81	1.02	.99	5.578	<.001
			Overweight	36	1.26	1.22	5.178	<.001
		FRL	Recommended	68	1.62	1.60	5.581	<.001
			Obese	31	1.68	1.63	3.223	.003
8th	Girls	Paid	Recommended	69	1.00	1.02	-3.791	<.001

Grade	**Gender**	**Lunch Status**	**BMI Percentile Classification**	**n**	**T1**	**T2**	**t**	**ϱ value**
7th	Boys	FRL	Obese	38	1.55	1.52	3.303	.002
	Girls	FRL	Recommended	68	.98	1.00	-2.837	.006

Notes: Baseline measurements were taken in both cohorts at the end of the academic school year in spring 2007. T1 measurements were taken in both cohorts at the start of the subsequent academic school year in fall 2007. T2 measurements were taken in both cohorts at the end of the subsequent academic school year in fall 2007. FRL = Free or reduced cost lunch

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