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Metabolic health and academic achievement in youth at risk for high school dropout in rural Mississippi: The role of classroom management

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ABSTRACT

Disparities in health and academic achievement affect large cross-sections of the same population subgroups. This study examined the relationship metabolic health and academic achievement in youth "at risk" for school dropout in rural Mississippi. Fifteen adolescents participated in a studio based learning educational summer camp and subsequent follow-up sessions during the regular school year that were aimed at developing knowledge of core curriculum subjects by developing design projects based on the camp STEM-related theme. These projects are characteristic of a pedagogical technique known as Studio Based Learning (SBL) and involve more movement than a traditional classroom setting. Participants' metabolic health was assessed via measurements of blood lipids and glucose, blood pressure, BMI and waist circumference, and examined individually and as a combined risk score. Academic achievement measurements were obtained from district standardized testing. Mean BMI for this sample was classified as overweight; however, other metabolic parameters (blood lipids and glucose, and resting blood pressure) were in normal ranges for this age group. Little association was found between metabolic health and academic achievement and in this sample for math of language ($r = -0.56$ and 0.20, respectively). Participants took part in notable amounts of moderate-to-vigorous physical activity during the SBL camp and very little in the traditional classroom setting (approximately 30 vs. 7 min/day, respectively). Actively engaging teaching strategies, such as SBL, may impart a meaningful impact on physical activity levels of school-aged children, which may have long term, positive health outcomes.

1. Introduction

Researchers acknowledge certain aspects of health as "educationally relevant" (Basch, 2011b), suggesting childhood obesity is linked with academic underachievement as well. Segments of the population who consistently are reported as having higher rates of obesity and lower levels of physical activity often comprise the same groups identified for greater educational disparities. For example, African American females and Mexican American males are the least physically active populations in youth, and also have a high percentage of school dropout (Basch, 2011c; Colquitt et al., 2011). Physical activity alone will not close the gaps in academic achievement and health disparities, but it does provide a means of directly targeting strategies to improve cognitive function (Best, 2010), while simultaneously benefiting multiple health-related parameters (Eisenmann, 2003).

Schools are ideal settings for targeted physical activity interventions in youth and often stem from physical education programs. A decline in physical activity opportunities within the school day can partially be attributed to schools' shift in focus from physical education to core curriculum due to the No Child Left Behind Act (NCLB) of 2001. Decreasing environmental cues contribute to the decline in physical activity over the lifespan. Given that the age-related decline in physical activity appears to be more severe among the same people who exhibit educational disparities (Basch, 2011c), it is critical to identify ways to increase physical activity opportunities in the everyday settings of this demographic.

Studio based learning (SBL) is a multidisciplinary approach in educational reform efforts that inherently incorporates physical activity into the learning process by a making and doing pedagogy. SBL is typically used in learning places centered on design and creation and has been shown to foster skills in higher-order thinking, knowledge transfer, professional literacy, collaboration, and motivation (Attoe and Mugerauer, 1991; Boyer and Mitgang, 1996; Schön, 1983). SBL time is spent in perpetual progression towards more technically accurate,

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artistically, and scientifically superior design proposals.

The purpose of this study was twofold: 1) investigate the relationship between metabolic health and academic achievement in a sample of youth who were identified as at risk for school dropout; and 2) examine the role a SBL environment may have on these variables.

2. Methods

2.1. Participants

Participants in this study are involved in a larger service project called Generation S-Studio School. Recruitment for this project is a multi-stepped process initiated each spring for over a decade. The process involves recruitment of students ranging from 5th through 12th grade from a single rural, high-poverty school district to maintain a 40-participant project total. Generally, new enrollees are middle school-aged. Principals and teachers select participants to refer, and then Generation S-Studio School staff make home visits to describe in full the experience to the referred students and their respective family members. Interested participants are then enrolled in the Generation S-Studio School program.

In a global sense, participants are defined by a myriad of characteristics known as "at-risk" for school drop out in the K-12 student performance literature. Empirical research data has shown high poverty, poor attendance, frequent behavior referrals, low academic grades, weak social connections at school, relative little extra-curricular involvement, low motivation as "at risk" characteristics (Freeman and Simonsen, 2015). For the present study, principals and teachers suggested possible participants based upon the presence of "at risk" qualities defined in the existing research literature. There were no participant exclusion criteria. Participants in the Generation S-Studio School project may choose to participate in the research portion of the work, but being a research participant is optional, provides no extra incentive, and does not provide for any difference in experience or treatment. This investigation examined the fifteen adolescents (4 females, 11 males) who participated in the 2013 Generation S-Studio School summer camp for which healthy snacks and transportation were provided. All participants provided assent and parental consent was obtained prior to collection of any data. This study was approved by the University Institutional Review Board.

2.2. Studio based learning environment

The Generation S-Studio School program is comprised of summer camp and academic year portions, and was created as an educational intervention strategy targeting kids at high risk for school dropout. Briefly, academic content is embedded in design problems presented to Generation S-Studio School participants to solve. The summer camp was structured as a two week day camp. During the academic year, participants took part in tutoring, various field trips and presentations, as well as assessment of relevant study variables.

Studio based instruction involves a "propose, critique, iterate" cycle of repetitive thinking and learning which provides participants opportunity to develop skills of higher-order thinking and self-reflection. Further, SBL provides several movement opportunities for learners, compared to the typical classroom setting. SBL has previously been described as an undertaking, a collaborative, a discovery, an integration, an application and a sharing (Lackney, 1999). These descriptors communicate the active nature of SBL pedagogy, and demonstrate a consistency with the National Association for Sports and Physical Education standard**s** 1 and 5 which require the physically literate to use motor skills and movement patterns as a part of learning and to value self-expression and social interaction. Likewise, the Monson and Poros definition emphasizes an increase in moderate to vigorous activity with multi-modal analysis, proposition, and critique in a space alive with movement (Monson and Poros, 2003). Learners have choices in a studio and are allowed to move about freely to consult and interact with the lived-in environment.

Within the present research setting, moderate to vigorous physical activity was incorporated by allowing participants to choose how they wish to design a physical activity into the academic regimen each day. Students were allowed to choose from a variety of equipment, games, partners, small group, large group, indoor and outdoor settings in which to consider movement as an act of redesigning self and redesigning school.

2.3. Anthropometry

Anthropometric variables were measured in duplicate by a single technician at Studio School Camp and again during the fall semester. Sitting and standing height were assessed using a portable stadiometer (Shorr, Maryland, USA). Weight was assessed using a digital scale that also calculated percent body fat via a foot to foot bioelectrical impedance analyzer (Tanita Corporation, Japan). Body mass index was calculated using weight and standing height. Waist circumference (WC) was measured in duplicate immediately above the iliac crest using a Gulick tape. Anthropometric measures were also used to calculate maturity offset (Mirwald et al., 2002), which was used to account for the various physiological differences due to maturity status.

2.4. Physical activity assessment

Accelerometer data collection took place during both weeks of camp and for one week during the school year. Upon arrival to camp, participants were fitted at the waist with an Actigraph GTX3+ accelerometer (Actigraph, Pensacola, FL). For the purpose of comparison, participants were given the same accelerometer during the subsequent fall semester to wear during the school day for one week, and only the hours corresponding with camp times were used in analyses. Accelerometers were distributed to participants before school and collected at the end of each day. Physical activity was reported as minutes spent in sedentary, light, moderate, and vigorous levels. Data were analyzed with Actilife 6 software using Evenson cut points (Evenson et al., 2008), in accordance with recent data processing recommendations (Trost et al., 2011).

2.5. Assessment of metabolic health parameters

An automated blood pressure cuff was used to determine systolic and diastolic blood pressures (Dinamap). To ensure resting measurements, participants sat quietly for at least ten minutes prior to assessment. Blood pressure was assessed twice, averaged, and used to calculate mean atrial pressure (1/3 Pulse Pressure + DBP).

Participants arrived at camp in a fasted state on the day of the blood sample. A 35 μL sample was collected and analyzed using a desktop analyzer (Cholestech LDX System) for blood glucose, triglycerides (TG), and lipoprotein cholesterol. The calibration of the analyzer was checked each day of use and accuracy is within industry standards (Bastianelli et al., 2017).

A composite risk factor, or metabolic syndrome score (MetS), was derived by summing the age-standardized residuals (Z-scores) for glucose, mean arterial pressure, high density lipoprotein cholesterol (HDL−C), TG, and WC (Brage et al., 2004). Because metabolic syndrome typically does not manifest until later in life, the use of a composite risk score allows each subject to have a risk indicator based on his/her current cardio-metabolic characteristics. A lower score is indicative of a better metabolic risk factor profile relative to the study sample.

2.6. Academic achievement

Academic achievement was determined using results from standardized curriculum testing. Exams were administered by school staff in the spring and fall semesters. The district provided test results for each participant within the study. The Measures of Academic Progress (MAP) test is given to students during the fall and spring semesters and provides the educator with a snap shot of the students understanding at that time. Educators then use results to develop targeted instructional strategies for individual classroom improvement. Evaluation scale extends from 100 to 300 and is based upon the district and grade level RIT (Rasch Unit) score. The RIT score is an estimation of a student's instructional level and measurement of progress in school. Academic measurements from the spring semester (prior to the academic intervention of Studio School) and the fall semester (after the summer camp portion of the academic intervention) are both considered here, as the raw RIT score and the corresponding categorical distinction (minimal, basic, proficient, and advanced), to examine a possible influence of the camp. Fall semester MAP scores were used for students at the middle school level. However, students who transitioned to the high school level ($n = 3$) took the Subject Area Testing Program 2 (SATP2), as it was used as Mississippi's benchmark assessment for high school students that year. Scores for the SATP2 were coded as minimal, basic, proficient, and advanced in order to make general comparisons with previous MAP performance. Because they most closely aligned with the assessment of other study variables at the camp, only spring semester testing results were used in correlation analyses, which addressed the primary aim of this study.

2.7. Statistical analyses

Descriptive statistics were calculated for all variables for the total sample, as well as boys and girls separately. Metabolic syndrome variables were examined individually and as a combined risk score. Two separate partial correlation analyses were conducted to examine the relationship between math and language, respectively, with MetS composite score. These correlational analyses were adjusted for maturity status and gender. Additionally, paired *t*-tests were used to compare the amount of moderate to vigorous physical activity (MVPA) achieved at camp to that achieved during the same time parameters in the course of traditional week at school. All analyses were conducted using SPSS (Version 23) statistical package and alpha was set at 0.05.

3. Results

Descriptive statistics of participants during the summer camp are found in Table 1. Mean height and weight approximated between the 50th and 75th percentiles when plotted on the growth charts (Ogden et al., 2002). BMI was greater than the 85th percentile when plotted on the growth chart (Ogden et al., 2002). In the total sample, both systolic and diastolic blood pressures were within the 50th percentile when charted on gender by age and height percentiles (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 2004). Mean fasting glucose was 83.3 (± 8.5) mg/dL and not considered concerning in for this age group. Total cholesterol, low-density lipoprotein, and triglycerides were also within normal ranges (Hickman et al., 1998) (143.6 mg/dL, 82.7 mg/dL, and 75.3 mg/dL, respectfully). High density lipoprotein was marginally higher than average (42.3 mg/dL) for the total sample (Hickman et al., 1998).

Measures of academic achievement, both mathematic and language test scores, are shown in Table 2. Raw scores show trends of improvement, however when categorized for skill level, a majority of raw scores are still below the proficient level for current grade. Table 3 shows partial correlations between math and language test scores, and metabolic health. After adjustment for gender and maturity status, metabolic syndrome composite score was not associated with math test scores ($r < -0.56$, $p = 0.20$) or language test scores ($r < 0.20$, $p = 0.66$). Several metabolic health variables (TG, HDL−C, GLU, WC, and BMI) were not significantly related to math achievement, but were in expected directions (i.e., healthier students had higher math achievement scores).

Table 1
Participant characteristics from summer camp. Values are mean (standard deviation) for total sample, male, and female for anthropometric and metabolic variables.

	Total sample ($n = 15$)	Male ($n = 11$)	Female ($n = 4$)
Anthropometric variables			
Age (yrs)	13.9 (± 1.3)	14.1 (± 1.2)	13.3 (± 1.6)
Height (cm)	163.7 (± 10.9)	166.1 (± 11.8)	157.0 (± 2.8)
Weight (kg)	62.6 (± 11.9)	64.1 (± 13.2)	58.3 (± 7.0)
Waist Circumference (cm)	77.2 (± 11.6)	76.9 (± 12.1)	78.0 (± 11.9)
% Body Fat	23.0 (± 10.4)	19.8 (± 10.0)	31.6 (± 5.8)
BMI (kg/m^2)	23.4 (± 4.6)	23.3 (± 5.1)	23.7 (± 3.3)
APHV (yrs)	15.3 (+0.6)	15.3 (+0.6)	15.4 (+0.8)
Metabolic variables			
MAP (mmHg)	78.5 (± 4.5)	78.2 (± 4.7)	79.5 (± 4.3)
SBP (mmHg)	112.5 (± 6.9)	112.6 (± 8.3)	112.1 (± 3.0)
DBP (mmHg)	61.9 (± 4.1)	61.4 (± 3.7)	63.1 (± 5.3)
Glucose (mg/dL)	83.3 (± 8.5)	82.1 (± 9.1)	86.3 (± 7.0)
LDL (mg/dL)	82.7 (± 23.5)	86.2 (± 27.2)	74.0 (± 11.3)
HDL (mg/dL)	42.3 (± 8.0)	40.5 (± 8.3)	47.0 (± 5.6)
Total cholesterol (mg/dL)	143.6 (± 18.0)	143.5 (± 20.7)	144.0 (± 11.5)
Triglycerides	75.3 (± 43.8)	71.3 (± 42.6)	86.0 (± 54.6)
MetS Score	−0.04 (± 3.4)	−0.3 (± 3.6)	0.7 (± 1.8)

BMI, body mass index; APHV, age at peak height velocity; MAP, mean arterial pressure; SBP, systolic blood pressure; DBP, diastolic blood pressure; LDL-C, low density lipoprotein cholesterol; HDL−C, high density lipoprotein cholesterol; MetS, Metabolic Syndrome.

A paired *t*-test was used to evaluate differences between physical activity attained during the summer camp and physical activity attained during the regular fall school year. Mean differences suggest that on average during camp participants spent 34.8 min in MVPA compared to 6.7 min in MVPA during the school year. These results suggest that participants received more MVPA during a studio based learning environment compared to a traditional school environment.

4. Discussion

Previous research suggests a link between academic achievement and metabolic health; specifically, health disparities and poor academic achievement have a cyclic influence on each other and tend to manifest in the same cross-sections of the population (Judge and Jahns, 2007; Yau et al., 2012). The purpose of this study was to investigate the relationship between metabolic health and academic achievement in a sample of youth who were identified as at risk for school dropout. A secondary aim of this study was examine the role a SBL environment may have on these variables in a short period of time. Results suggest that metabolic health was not related to academic achievement within this sample. Likewise, little variability was observed among raw test scores between the pre-test administered during spring prior to the Studio School summer session and the post-test taken during the subsequent fall. Although test scores improved for some students, most test scores were still considered to be failing by district standards.

The modest association between MetS scores and academic achievement in mathematics ($r = -0.56$) was in the expected direction (i.e., lower MetS scores were associated with higher achievement in mathematics). There was little association between language test scores and metabolic health ($r = 0.20$). The low variation in scores, both between and within subjects, partially explains the modest relationship observed in the present study. Academic achievement testing scores were divided into four categories, minimal, basic, proficient, and advanced. Most participants scored within the minimal and basic

Table 2
Participant characteristics: measures of academic achievement.

Academic achievement	Total sample (n = 15)	Males (n = 11)	Females (n = 4)
Spring MAP Test Math Score	209.8 (± 10.8)	209.6 (± 8.7)	210.3 (± 16.3)
Fall MAP Test Math Score	206.9 (± 11.4)	201.8 (± 4.9)	213.7 (± 14.6)
Fall SATP2 Math Score (9th grade students only)	651.3 (± 13.3)	653.0 (± 18.4)	648.0 (± 0)
Spring MAP Test Language Score	209.8 (± 10.8)	209.6 (± 8.7)	210.3 (± 16.3)
Fall MAP Test Language Score	197.7 (± 18.4)	188.3 (± 18.2)	210.3 (± 10.0)
Fall SATP2 Language Score (9th grade students only)	644.0 (± 1.4)	645.0 (± 0.0)	643.0 (± 0.0)

Values are mean raw test scores (standard deviation) for total sample, male, and female.

Table 3
Associations between academic achievement and metabolic health.

	Math	Language
MetS score	−0.56	0.20
HDL-C	0.63	0.42
Glucose	−0.39	0.58
TG	−0.54	0.20
MAP	0.21	0.28
WC	−0.63	0.01
BMI	−0.57	0.22

MetS, Metabolic Syndrome; HDL-C, high density lipoprotein cholesterol; GLU glucose; TG, triglycerides; MAP, mean arterial blood pressure; WC, waist circumference; BMI, body mass index.

categories both for pre-and post-assessments of math and language. Three participants scored lower on the post-assessments, which may be indicative of confounding influence by psychosocial variables. Florin and associates (Florin et al., 2011) suggest that pediatric obesity may negatively impact relationships formed with peers and teachers, which may, in turn, decrease the ability to pay attention during school. Likewise, these interrelationships among pediatric obesity, psychosocial variables, and academic achievement may also be examined through the lens of classroom engagement. Low engagement in the classroom, negatively impacts academic achievement and is directly related to social interactions among peers in learning settings (Basch, 2011a; Florin et al., 2011). A major focus of the SBL summer camp was to promote positive relationships with peers and authority figures. Perceptions of connectedness and mutual respect take time to develop and may not translate from the camp setting into the traditional classroom. If students do not feel motivated to perform well or interact within the classroom, it stands to reason that content knowledge and retention will also be affected. Future research should expand upon psychological factors like motivation and attitude and potential effects on this at-risk population.

A noteworthy aspect of the present study was the potential of addressing physical inactivity in youth in a unique way that may positively influence health and academic achievement. In this study, students spent an average of 6.7 min in MVPA per day when they were in the traditional school environment. In stark contrast, when those same students were placed in a studio based learning environment during the summer camp for half of the time of a regular school day, they achieved an average of 34.8 min of MVPA per day, which is over half of the federally recommended amount (Physical Activity Guidelines Advisory Committee, 2008). Given that youth spend a large segment of their day in school, studio based learning and other actively engaging teaching strategies may impart a meaningful impact on the physical activity levels of this age group.

Albeit small, this study's sample of at risk, minority participants is a strength for this type of preliminary investigation. We were able to study the demographic for whom dropout prevention strategies and alternative learning environments are intended, which ultimately allows for more expedited translation of findings into practice. The low engagement nature of this group makes acquiring large sample sizes with adequate adherence to study procedures, very problematic. This study was strengthened by the objective measurements of health-related variables and physical activity. However, a larger sample size would allow for examination of possible gender differences in response to intervention in terms of academic achievement and physical activity accumulation.

The direct influence of physical activity on improvements in academic achievement are still unclear; however available research does suggest that physical activity directly benefits cognitive function (Hotting and Roder, 2013; Tompkins et al., 2012), likely through executive function (Best, 2010). Previous investigations by Donnelly and colleagues suggest that students are more likely to be active when play was incorporated into curriculum as opposed to other approaches where involvement is optional (Donnelly et al., 2013). Coe suggests that the intensity of the physical activity may also play an important role in disambiguating the association between physical activity and academic achievement (Coe et al., 2006). Classroom reform efforts such as studio based learning encourages movement throughout the lesson through making and doing activities, which add to the total physical activity opportunities of a child.

The present study yielded few statistically significant findings, however, research efforts of this nature are critical exploratory steps towards identifying intervention strategies that positively influence multiple aspects of development. Studio based learning creates an effective learning environment that is also conducive to promoting physical activity during the school day by providing goal-oriented, structured activity. Implementation of multidisciplinary strategies such this will be critical in addressing the educational and health disparities co-occurring in many cross sections of the population. While these results are not conclusive, practitioners should not feel hesitant to employ teaching strategies that provide opportunity for increased movement whenever possible. Physical activity is an avenue by which educators can directly target cognitive function (Best, 2010), while simultaneously favorably influencing multiple aspects of health (Eisenmann, 2003), both of which are ultimately linked with academic achievement. Multidimensional strategies are essential in making meaningful strides at narrowing the gap in academic achievement and health disparities that co-occur in certain cross sections of the population.

Conflict of interest

The authors declare there is no conflict of interest.

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