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An ecological approach to understanding academic achievement: Considering intrapersonal, physical activity, and support variables.

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Considering Physical Well-being, Self-Perceptions, and Support Variables in Understanding Youth Academic Achievement

ABSTRACT

The purpose of this study was to examine the relation between measures of students' physical well-being and self-perception and their academic achievement. Specifically, we look at students' social support for physical activity, physical activity perceptions, self-concept, self-efficacy, health behaviors, and cardiorespiratory fitness (as measured by the PACER test). Students (n = 697 fifth graders) were surveyed at the beginning of the school year. A two-group path analysis revealed notable relationships between the predictor variables and proximal and distal outcomes, with some paths moderated by sex. One relationship that was significant for both sexes was cardiorespiratory fitness, as it was the only significant predictor of achievement. This effect was moderate to large for the female students (R^2_{Math} = 36%; R^2_{Read} = 15%) and small to large for the male students (R^2_{Math} = 26%; R^2_{Read} = 10%). These findings can be used to guide future research and educational prevention and intervention efforts.

It is well-established that academic achievement (hereafter named “achievement”) is a critical indicator of future success, as poorly performing youth are at increased risks of negative socioeconomic life trajectories (Hahn et al., 2015; Veldman et al., 2015). In addition, the early adolescent transition from elementary to middle school is also known to be wrought with interruption in achievement (Akos, Rose, & Orthner, 2014). Securing a solid academic foundation prior to the entrance of middle school is critical to making a successful transition. Therefore, studying achievement in the upper elementary school age group prior to the adolescent transition is especially important. The factors that best predict achievement have been studied through multiple lenses. In this study, we conceptualized predictors of achievement through the lens of Bronfenbrenner’s ecological systems theory (1979). From this theoretical perspective, individuals develop within nested structures. At the center of the model is the self/child, surrounded by four layered external systems--microsystem (family, home, and school), mesosystem (interactions between microsystems), exosystem (indirect influences on children), and macrosystem (overarching cultural influence). Of focus in the current paper were variables from the self and microsystem levels.

Through an ecological lens, it is conceptualized that achievement is explained by a combination of relationships that are reciprocal and/or inter-related among these layers. In the current study we drew from several disciplines in building a model to predict academic achievement. For example, in the fields of general education and developmental psychology, it is most common that individual and school level variables are examined to better understand the achievement of students. In other fields, such as physical education, variables of physical activity (PA) and fitness have been examined in relation to achievement. Although achievement has been studied extensively within these individual contexts, it is uncommon for research teams to cross

disciplines and blend factors typically limited to study in their respective fields, thus leaving a gap in the literature understanding the collective impact on achievement. Specifically, those in general education and developmental psychology tend not to consider the roles of such factors as physical activity, nutrition, and health self-concept. Similarly, in the physical education fields, it is not common to see inclusion of factors like school attachment and self-esteem. Including these variables together in the pursuit of maximally understanding academic achievement is the gap that we see in the literature.

Parents, peers, and teachers/school personnel all play an important role in child development. Specifically, variables at the parent level have been shown to be predictive of children's achievement, including parental social supports (both of an academic and practical nature) (Wang & Sheikh-Khalil, 2014) and clear parental academic expectations (Hill & Tyson, 2009). School variables also contribute, including school climate (Thapa, Cohen, Guffey, & Higgins-D'Alessandro, 2013), teacher support (Stroet, Opdenakker, & Minnaert, 2013; Wang & Eccles, 2013), and quality of teacher-student relationships (Malecki & Demaray, 2002). Additionally, peers have been shown to have an influence on variables such as study habits (Wentzel, 1993), and peer support has been associated to a small but significant degree with better achievement (Chen, 2005). Various intrapersonal factors also have consistently been associated with achievement, including general and academic self-efficacy (Chang & Chien, 2015; Schunk & Zimmerman, 2012), behavioral engagement (Balfanz & Byrnes, 2006), help-seeking behavior (Ryan & Shim, 2012), and self-confidence (Lowe & Dotterer, 2013). Thus, support for PA from multiple systems (parents, peers, teachers, principals) was included in the current study as proposed predictors of achievement.

In the field of physical education, researchers have examined the impact of PA and fitness on achievement. Over the past 40 years, research has shown positive relationships among academic success, cognition, and youth physical fitness and PA levels (Basch, 2011; Castelli, et al., 2014; CDC, 2010; Sibley & Etnier, 2003). Given the push for children to achieve at high levels, coupled with a more recent push of school reform to focus on the success of the whole child, better understanding these relationships is important (Lewallen, Hunt, Potts-Datema, Zaza, & Giles, 2015). Specifically, researchers have shown that students with higher levels of cardiorespiratory fitness are more likely to succeed academically (Castelli, Hillman, Buck, & Erwin, 2007; Srikanth, Petrie, Greenleaf, & Martin, 2015; Van Dusen, Kelder, Kohl, Ranjit, & Perry, 2011). Other researchers have shown a direct, positive link between fitness and executive function, which in turn can impact achievement (Castelli, et al., 2014). Additionally, although the literature is not quite as strong as that related to cardiorespiratory fitness, scientists have shown a positive relationship between moderate to vigorous PA and children's academic performance in school (Centeio et al., 2018; Donnelly & Lambourne, 2011; McPherson, Mackay, Kunkel, & Duncan, 2018). Donnelly and Lambourne (2011) examined children's levels of PA in relation to their academic test scores and reported that children who participated in moderate PA through classroom interventions scored higher on an achievement test. Similarly, Centeio and colleagues (2018) found that in a comprehensive school health intervention, children's number of steps directly impacted their success in math, but not in reading. Most recently, McPherson and colleagues (2018) found a direct relationship between physical activity and academic performance of primary school children. The effect also accounted for cognition which seemed to mediate the relationship. Based on this, students' PA and cardiorespiratory physical fitness were included as expected predictors of achievement in the current study.

Other expected predictors of achievement were students' attachment to school, global self-esteem, enjoyment of PA, global health self-concept, nutrition attitudes and efficacy, and daily nutrition/eating behavior. Greater attachment to school and school related engagements has been shown to predict higher GPA among youth (Bryan et al., 2012; Lecroy & Krysik, 2008; Valverde, 1987). In one study that looked at Hispanic graduates and non-graduates, students who graduated were more likely to have a strong support system of academically able friends than students who did not graduate (Lecroy & Krysik, 2008). Self-esteem and self-concept are also positively related with academic achievement (Choi, 2005; March & Craven, 2005, Peixot & Ameida, 2010), but the literature is not so clear in regards to the relationship between nutrition and achievement. Shaw (2015) purported that the assumed direct and positive influence of nutrition on academic achievement is more complex and may have multiple, alternative explanations. In addition to measuring overt daily nutrition/eating behavior, related constructs of nutrition attitudes and efficacy, enjoyment of physical activity, and global health self-concept are hypothesized to contribute to the overall variance in achievement. Therefore, each of these constructs was also included in the current study as expected contributors.

In addition to our view through the lens of ecological systems theory guiding this selection of variables, we also conceptualize two levels of outcomes: (1) proximal outcomes (i.e., social-emotional, nutritional, and PA/fitness outcomes), and (2) distal outcomes (math and reading achievement). In this vein, some variables that we believe to ultimately predict achievement may actually function as intermediary steps in the path to the ultimate outcome of interest—academic achievement. In a sense, we conceptualize both proximal and distal outcomes as developing/occurring simultaneously, but with the proximal variables as somewhat "intermediary" and the distal variables (achievement) as potential extensions of them. This study

was designed within the ecological framework because we were interested in both the ultimate path to achievement but also what we conceptualize as an intermediary step to more proximal variables that could also be conceptualized as types of outcomes. Our variable selection was driven by a thorough empirical literature review, which we mapped onto the ecological systems perspective and ultimately used to secure this comprehensive composition. This framework lends itself to tests of how these variables relate to potentially explain our end goal variable of interest—academic achievement.

Additionally, there is an important literature base that suggests sex differences in achievement of youth (Pomerantz, Altermatt, & Saxon, 2002; MarcenaroGutierrex, Lopez-Agudo, & Ropero-Garcia, 2017; Marsh & Yeung, 1998). For example, according to Francis & Skeleton (2005), males are, in general, achieving less in the areas of literacy than females and there is evidence that points that this difference may lie in the socialization of children and how males and females interact with the education process differently. In math, there seems to be initial sex differences among males and females, with males scoring favorably, however, the sex difference overall in math achievement tends to be small (Lindberg, Hyde, Petersen, & Linn, 2010). There is also some research that points to differences in self-regulation in preschool, explained by sex (Matthews, Morrison, & Ponitz, 2009), and the impact on achievement that may take until elementary school to be observed. Other studies highlight the important role of socioeconomic status and even its intersection with sex in impacting achievement (Entwisle, Alexander, & Olson, 2007). In any case, there are sex differences that are present within the achievement literature, so in our study, we hypothesized that there would be important differences in relationships among our selected variables. Thus, we analyzed patterns for females and males separately.

Purpose of the Current Study

This review of literature highlights the need to draw from several levels of potential influence on academic achievement and reveals the need to integrate research across several academic disciplines studying achievement. Therefore, we attempted to address the complexity of influences that have been studied by different specialists to enable us to expand our ability to explain variance in achievement. Therefore, the purpose of this study was to explore a selective group of potential predictors of achievement to better understand both the unique and additive contributions of these variables to children's academic achievement. The two specific aims of this study were: 1) To better elucidate the link between physical activity and academic achievement through testing a broader model including pathways through more proximal outcomes, and 2) To understand whether and how these paths vary for males and females.

Method

Participants and Procedures

Participants included 697 5th grade students (M_{age}= 9.96; *SD* = .38; female = 50.8%) across seven suburban elementary schools in the Midwestern United States. Students' were Caucasian (44.7%), African American (19.7%), Asian (9.0%), Multi-Racial (7.7%), Arab American (5.3%), Hispanic (3.3%), and other categories (7.9%).

After IRB approval, parental and student consent was obtained. The data was collected at the beginning of the school year (September 2015) and surveys were read out loud to each classroom and students followed along as each question was read. Students' age, sex, and race were self-reported by each student while completing the survey.

Measures

Perceived social support. Perceived social support for PA was collected from the students

in relation to their classroom teacher, principal, classmates, and caregivers/parents. The perceived social support scale was originally developed by Duncan and colleagues (Duncan, Duncan, & Strycker, 2005). Kulik and colleagues (2014) adapted the scale to include school based supports (i.e. teachers, principals, and classmates) and confirmed validity among elementary school students (Kulik et al., 2014). Each subscale used in this study (classroom teacher, principal, classmates, and caregivers/parents) includes four types of support factors (encourage, do with, watch, talk). For example, how much do your classroom teachers encourage you to do physical activities? Students chose from a 5-point Likert scale with the stems of never (1) to very often (5). Cronbach's alpha for each source was acceptable ($\alpha_{\text{classroom teacher}}$ =.64; $\alpha_{\text{principal}}$ =.72; $\alpha_{\text{classmates}}$ =.67; α_{parents} = .74).

Physical activity enjoyment. The Physical Activity Enjoyment Scale (PACES) is a 16-item scale (Kendzierski & DeCarlo, 1991) that was later validated by Moore and colleagues (2009) in a similar elementary age group to this study (Moore et al., 2009). The PACES is measured on a 5-point Likert scale that ranges from (1) disagree a lot to (5) agree a lot. There is a general stem used "When I am physically active" followed by a statement such as "it feels good." Cronbach's alpha in our sample showed good reliability among the sample (α=.90).

Health self-concept. The health self-concept scale is a 5-item subscale taken from the PSDQ-S (Marsh, Martin, & Jackson, 2010). This scale is based on a 6-point Likert scale ranging from False (1) to True (6). An example question of this subscale is "I am sick so often that I cannot do all the things I want to do." The items were reverse-coded, and then averaged, so the higher the score, the higher a student's health self-concept. Cronbach's alpha for this scale showed moderate reliability among the sample (α=.79).

Nutrition attitudes and efficacy. The nutrition attitude-efficacy scale was created to

determine children's efficacy and attitudes towards nutrition behaviors. This 16-item scale asks children to answer questions on a 5-point Likert scale, with stems specific to attitude or efficacy, respectively (Kulik et al., under review). Two example questions are "How do you feel about eating fruits?" (attitude) and "I can read food labels to know if a food is a whole grain" (efficacy). The variable factor structure was initially examined with cross-sectional data using an exploratory factor analysis that supported a single factor solution, which was then tested with a longitudinal confirmatory factor analysis; the CFA provided additional evidence (i.e., factor loadings, close model fit, and McDonald's omega above .70) supporting that the items of this scale make a single nutrition attitudes and efficacy variable (Kulik et al., under review). Furthermore, the above study presented validity evidence for this construct was its significant correlation relationships within and across time with nutrition knowledge (r = .15 to .29) and healthy eating index scores (r = .20 – .39); nutrition knowledge and nutrition attitude-efficacy each uniquely and significantly predicted students' future healthy eating index scores. Cronbach's alpha for this scale showed good reliability (α=.78).

School attachment. The school attachment measure consists of 7-items that are on a 5-point Likert scale ranging from definitely no (1) to definitely yes (5) (Somers & Gizzi, 2001). Sample questions from this scale include "Do you like attending school?" and "Are you proud of your school?"Cronbach's alpha in our sample showed good reliability (α=.81).

Global self-esteem. The global self-esteem measure was a 5-item subscale from the Physical Self-Description Questionnaire (PSDQ-S; Marsh et al., 2010). The 6-point Likert response scale ranged from False (1) to True (6). An example question is "Overall most things I do turn out well." Cronbach's alpha in our sample was good (α=.78).

Physical activity. Student PA was collected using the Children's International Physical

Activity Questionnaire (IPAQ- C; Kowalski, Crocker, & Faulkner, 1997). The IPAQ-C was chosen because it is age appropriate and represents 7 days of PA both inside and outside the school setting. The IPAQ-C consists of 10 items that ask various questions about PA participation in the past 7 days. Cronbach's alpha for our sample was good (α=.88) and the correlational analysis between the individual IPAQ items and total PA variable showed at least moderate correlations (.30 and above).

Cardio-respiratory endurance. The progressive aerobic cardiovascular endurance run (PACER) test was used to assess aerobic capacity (Welk, Morrow & Falls, 2002). This is a common field test to measure cardiovascular endurance of youth in a school setting where students run to a cadenced beep for 15- 20 meters (depending on the protocol), with the cadence becoming shorter as the test prolongs. The PACER test was administered by the lead researcher and trained research assistants to ensure consistency in test administration.

Fruit consumption and vegetable consumption. Fruit intake and vegetable intake were measured separately using two questions on fruit intake and one on vegetable consumption from a modified SPAN questionnaire with a history of producing valid and reliable scores with similar populations (Fahlman, McCaughtry, Martin, Garn, & Shen, 2012). These and similar questions have demonstrated validity and reliability and used as stand-alone measurements for fruit and vegetable consumption in the elementary population (Fahlman, et al., 2012; The Network for a Healthy California, 2010). An example of a question is "Yesterday, did you eat any vegetables? Vegetables are all cooked and uncooked vegetables; salads; and boiled, baked and mashed potatoes." Students were given six choices that ranged from "0 times" to "5+ times."

Academic achievement in reading and math. The Academic Improvement Monitoring System (AIMSweb; www.aimsweb.com) and the Dynamic Indicators of Basic Early Literacy

Skills (DIBELS; www.dibels.uoregon.edu) system are two different sets of brief, direct measures of academic skills commonly used in K-12 schools as universal screening tools to determine the attainment of grade level benchmark skills. Skills tested reflect generally consistent benchmarks across school buildings, districts, and states, and are sensitive to change over time. Raw scores in math computation (using AIMSweb) and reading comprehension (using DIBELS Daze) were collected. Curriculum-based measures (CBMs) have produced valid and reliable scores in previous research (e.g., Deno, Shin & Espin, 2000; Fore, Burke & Martin, 2006; Tindal, Helwig & Anderson, 2002).

Data Analysis

We first examined the data to determine if multivariate research assumptions were violated, examined for and managed missing data, and then examined our descriptive results (e.g, means, standard deviations). Finally, we conducted our major analyses (i.e., path analysis). The distribution was normal. There was 4.5% missing data, which was handled with multiple imputation to produce 100 imputed datasets for the analyses. Prior to the imputation, a principle component analysis was conducted with the overall dataset at the item level and the components saved to be used in the imputation process to represent any and all interaction effects between the variables in the dataset (Howard, Rhemtulla, & Little, 2015). The imputation was conducted in R with the mice package. The imputation model included all of the items of the dataset, plus the principle components as auxiliary variables. The relative efficiency of the parameter estimates was .999 to 1.00, which supports the imputation approach used for handling the missing data, including the number of imputations (Jia, Moore, Kinai, Crowe, Schoemann, & Little, 2014). Descriptive statistics and the path analysis were conducted with these 100 imputed datasets.

To test the hypothesized predictive paths from the predictor variables to the proximal outcomes and finally to achievement for each sex, a two-group (for each sex) path analysis in Mplus 7.0 was conducted (Muthén, & Muthén, 1998-2012). Path analysis was selected as the most appropriate statistical procedure to answer these questions because all the relationships are tested simultaneously and all variables can also be correlated within the model to relevant variables, which is more representative of real-world relationships, than other analyses, such as stepwise regression. As the students were within classrooms, there was a natural nesting to the data, such that students in one classroom are not fully independent, and are more homogenous with each other than with students in another classroom. This was highlighted by the fact that the students' PA level differed across some of the classrooms. Therefore, to account for the nested nature of the data, the cluster option was utilized in Mplus at the classroom level; the cluster option scales the chi-square statistic based upon the homogeneity within classrooms compared to between them (Muthén, & Muthén, 1998-2012). Finally, the path analysis included the students' race as coded variables that all the other model variables were regressed on to control for any race effects.

Results

The means, standard deviations, and correlations are reported in Table 1. The participants reported that, on average, their caregivers and classmates provided social support to a moderately often degree for their being physically active, whereas their principal and teacher sometimes supported their being physically active. The participants also reported being "sort of" attached to their school. The students reported being healthy, having a high level of general self-esteem, enjoying PA, and participating in physical activities 3.5 days a week. They also reported eating two fruits and two vegetables a day, on average. The students' performance on the reading and

math assessments was average (compared to national norms) and cardiorespiratory assessment (PACER) was also average compared to fifth grade national norms. The only two mean values that were moderated by sex were the students' cardiorespiratory performance and reported subjective PA; for both of these variables, the males' values were significantly greater than the females' values.

The fully specified path model with all variables related to all other variables in the model through either regression or correlation paths had perfect model fit (χ_0^2 = 0.00, CFI = 1.00, NNFI = 1.00, SRMR = 0.0, RMSEA = 0.00). As this fully specified model always has perfect fit in path analysis (Muthen & Muthen, 1998-2012; Geiser, 2013), alternative models are tested against it to determine a more parsimonious model (i.e., fewer regression paths) that represents the data as well, without significant loss of model fit (i.e., misfit to the data). Then, to test how well the more parsimonious model fits compared to the fully specified model, the nested model chi-square difference test is utilized. Given the complexity of this model and sample size, the alpha level was set to .001 for the nested model chi-square difference tests (Kline, 2016; Little, Card, Slegers, & Ledford, 2007).

Based on ecological theory and prior research, a hypothesized model (see Figure 1) was developed. When this hypothesized model was assessed, it fit the data significantly worse than the fully specified model ($\Delta\chi_{62}^2$= 191.45, p <.001). Given the magnitude of the misfit of this model, a more data-driven approach was utilized, and the nonsignificant paths for each outcome variable were pruned (i.e., constrained to 0), and the subsequent model tested for fit. The pattern of significant regression paths differed by sex, therefore, the pruning of nonsignificant paths differed by sex. A final, parsimonious model with all nonsignificant regression paths was reached for both the male and female models that did not suffer from significant model misfit (χ_{115}^2 =

228.021, CFI = .993, NNFI = .966, SRMR = .04, RMSEA = .053). The final model revealed differences for each sex in the pattern of relationships between some of the constructs (See Figures 2 and 3).

For both males and females, the only significant predictor of the distal outcomes, achievement, was PACER performance (cardiorespiratory fitness). A greater percentage of the variance was accounted for in both math and reading outcomes in the female model (R^2_{Math} = 36%; R^2_{Read} = 15%) than in the male model (R^2_{Math} = 26%; R^2_{Read} = 10%). According to Cohen (1988), 10% is a small effect size, 15% is a moderate effect size, and 26% and 36% are large effect sizes. PACER performance was significantly predicted by PA enjoyment for females (β = .23, $p < .001$) and by classmate social support for males (β = .19, $p < .001$). PA enjoyment also significantly predicted students' subjective PA levels (β_{female} = .30, $p < .001$; β_{male} = .45, $p < .001$); males' reported social support from parents for PA also predicted their subjective PA levels (β = .33, $p < .001$). Fruit (β_{female} = .22, $p < .001$; β_{male} = .19, $p < .001$) and vegetable consumption (β_{female} = .32, $p < .001$; β_{male} = .27, $p < .001$) were predicted by students' reported nutrition self-efficacy/attitudes, regardless of sex. School attachment was significantly predicted for females by health self-concept (β = .22, $p < .001$) and nutrition self-efficacy/attitudes (β = .32, $p < .001$), whereas males' school attachment was predicted by teacher social support (β = .15, $p < .001$), classmate social support (β = .19, $p < .001$), PA enjoyment (β = .23, $p < .001$), and nutrition efficacy/attitudes (β = .18, $p < .001$). Finally, female students' global self-esteem was predicted by their PA enjoyment (β = .36, $p < .001$) and their health self-concept (β = .18, $p < .001$), whereas males' global self-esteem was not predicted by any of variables. Thus, 16% of female students' global self-esteem was explained compared to 1% of males' self-esteem by these models.

Discussion

Path analyses moderated by sex were conducted to determine the relation between measures of students' physical well-being and self-perception and their academic achievement. Across each set of analyses, PACER performance predicted both reading and math for both males and females. Similar to previous research, implications are clear that impacting cardiorespiratory fitness is an important place to intervene if trying to improve the achievement of youth (Van Dusen, Kelder, Kohl, Ranjit, & Perry, 2011; Wittberg, Northrup, & Cottrell, 2012). However, the mechanism of action underlying this relationship was different for males and females. Therefore, an analysis of which variables predicted the relatively more proximal outcomes (social-emotional, nutritional, and PA/fitness outcomes) is important. For females, PA enjoyment was a predictor of students' cardiorespiratory fitness (PACER performance); however, for males it was receiving social support for PA from classmates that predicted cardiorespiratory fitness. The distinctions highlight areas that are important to include when intervening to increase the cardio-respiratory fitness and academic achievement of all youth.

Several factors were significant predictors of the proximal outcomes. Although those behaviors were not direct predictors of achievement in this sample, those outcomes contributed to the overall model and variance of achievement in both reading and math. Furthermore, many of the predicted proximal outcomes are important in and of themselves, and a noteworthy differential pattern by biological sex was found. For example, predictors of PA among males included parental social support and PA enjoyment, suggesting that the more parents supported PA for their boys and the more boys enjoyed PA, the more active they were. This, however, did not hold true among females, as PA enjoyment was the sole predictor of PA participation. This is interesting given that previous literature found parental support is significant in influencing both

males and females physical activity levels (Beets, Cardinal, & Alderman, 2010). Although the current study did not look at differences in support among males and females, Beets and colleagues (2010) suggest in their comprehensive literature review that boys tend to receive more parental support than girls do. Maybe an added level of PA support for boys could play in a role in the relationship. Similarly, PA enjoyment was a significant predictor of PACER performance in females, while this relationship did not hold true among males, for whom classmate social support was the only significant predictor. This is also an interesting finding as it seems that in this sample, males who perceived higher social support for PA had higher participation in PA and higher levels of fitness, whereas among the females in this study, PA enjoyment had the most influence on both participation and fitness. Previous studies have shown, regardless of sex, physical activity enjoyment is a key determent of overall PA participation (Dishman et al., 2005; Remmers, Sleddens, Kremers, & Thijs, 2010), but little research has been conducted on the relationship between social support and PA enjoyment on cardio-respiratory fitness. Future research should examine social support in relation to fitness for both males and females, as we might have expected to see a social environment influence for females and males, rather than just for males (Sallis, Prochaska, & Taylor, 2000).

Global self-esteem was another proximal outcome that varied by males and females. Among females, global self-esteem was predicted by PA enjoyment and health self-concept. However, these relationships were not seen among males in this sample, as there were no significant predictors of global self-esteem. This is consistent with a recent large scale comprehensive study conducted to help understand inconsistent findings over time regarding self-esteem, sex, and culture (Helwig & Ruprecht, 2017). In a large-scale sample of over 45,000 participants, the authors found consistent self-esteem differences by sex and across cultures,

including lower self-esteem among females between the ages of 10 and 30 and similar male and female patterns over time. Within our current sample, those females who enjoyed PA and had a higher health self-concept also had a higher level of global self-esteem. This demonstrates the interrelated nature of PA and sense of self in terms of both how one describes and feels about herself and how one behaves. Thus, the complex nature of this relationship should be factored into future ecological systems-based intervention designs. When trying to increase PA, for example, it will be important to connect PA to sense of self (concept and esteem), while taking the culture and sex of the students into account.

Not surprising in these findings is that students' (both females and males) nutrition efficacy and attitudes were significant predictors of their fruit and vegetable intake, which, regardless of sex, has been shown to be very low (e.g., Nunez et al., 2015). Their nutrition efficacy and attitudes were also significantly, positively correlated with their health self-concept, though not as strongly as health self-concept was to PA. This is important for designing interventions that focus on increasing students' overall health, including fruit and vegetable intake. Essentially, by increasing students' overall conception of health to include nutrition, as well as their efficacy and attitudes towards eating fruit and vegetables, it could help increase consumption of fruits and vegetables.

Finally, in this sample, predictors of school attachment were also different for males and females. This is consistent with other research on school attachment that shows differences by sex (e.g., Kirkpatrick, Crosnoe, & Thaden, 2006; Pearson, Muller, & Wilkinson, 2007). Previous literature has shown that females had higher school attachment in middle school, while males showed higher attachment in high school (Johnson, Crosnoe, & Elder, 2001; Kirkpatrick, Crosnoe, & Thaden, 2006). In the current sample, although levels of school attachment by sex

was not examined, the predictors of school attachment varied by sex. Explanations for these differences should be examined in future research. In this study, both females' and males' school attachment was significantly predicted by nutrition attitudes and efficacy, females' health self-concept was a significant predictor of school attachment, and males' PA enjoyment and social support for PA from classmates and teachers were also significant predictors. Nutrition and school attachment do not appear to have been studied together in this way before the current study. Although preliminary, there appears to be a connection that could be capitalized on that goes beyond the scope of this study. For example, helping students make the link between feeling good about being at school (attachment) and their own eating habits is important. Additionally, the provision of quality food that youth enjoy in school could lead them to feel more attached to the school, particularly among students who may receive the majority of their food from the school setting. Especially in schools, eating tends to be a social activity with potential for influence of peers. Explicit emphasis on supporting each other in healthy eating initiatives could help children feel more connected to school in general. These connections might stimulate an improved sense of importance around nutrition. Of course, this association requires more exploration in future research to more fully understand this relationship and how it can be positively influenced through school interventions. These data can also begin to add to the literature base as there is limited research, if any, that focuses on school attachment, social support for PA, PA enjoyment, and nutrition behavior.

A general observation in these findings is that there are paths to both the proximal and the relatively more distal outcomes, and those paths are different for males and females. For example, although the means were not statistically different for males' and females' reported PA social support by significant others, the females' values were all closer to "neutral" than the

males' values. This may represent a meaningful difference in how females are being overtly or covertly socialized regarding PA involvement. Subtle differences that may not be statistically significant may be enough to have a meaningful effect on how physically active students are, and how connected they feel to their school. As both PA levels and cardiorespiratory fitness are important for students' health and achievement, it is important that teachers and school administrators are cognizant and receive feedback regarding even subtle differences in their supportive messages regarding students' participation in PA.

Sex differences in our model may provide insights into how to tailor interventions for males and females. Also, although both reading and math were predicted by PACER performance for males and females, a higher proportion of variance was explained in math than in reading. Namely, over 25% of the variance in math was explained, whereas up to 15% of reading was explained by PACER performance. This may have implications for how males and females respond to interventions to improve cardiorespiratory fitness as a tool for improving math and/or reading. Knowing the differential relationships demonstrated in research could help schools focus their efforts, when judging which interventions may prove most effective.

While the fields of general education, developmental psychology, and physical education have individually examined predictors of achievement from an ecological perspective, it is uncommon for the variables that are typically measured within different fields to be blended together into one study (e.g., physical activity, nutrition, health self-concept, school attachment, self-esteem, etc). The results of the current study show that through an ecological lens there are combination of relationships that are reciprocal and/or inter-related when predicting academic achievement of youth. It is evident that when trying to impact youth achievement, multiple disciplines should work together to collectively examine a holistic view of the child and how

variables interact with each other to, in turn, impact academic achievement. This study has also highlighted the importance of understanding each variable in relation to biological sex, as this may play an important role in intervention design to improve achievement in the future.

Limitations and Directions for Future Research

The current study is not without limitations. First, this data is cross-sectional, therefore not showing causality, so readers are cautioned on interpretation. Furthermore, although a large sample, these data were collected among suburban children and relationships might not hold true among all elementary school students. Third, PA data within this study was subjective and different results might show with objectively measured PA. Related to this, although students were encouraged and reminded to answer honestly and it was explained that there were no "right" answers, socially desirable responding is always a risk in self-report survey research.

Given the need to understand the whole child in relation to achievement, understanding the contributing roles of students' physical well-being and self-perception, including physical activity, fitness, and nutrition is important. Future research is needed to understand how interventions that target some of these influencers can impact achievement. Furthermore, it is important to better understand some of the differences and reasons why these relationships were not consistent among males and females, or even for different types of achievement (i.e., reading and math). Qualitative designed research, specifically interviews with youth, might help to tease out some of the reasons for these discrepancies, and could help to better understand the nature of these inconsistent predictors of math versus reading.

Conclusions

Taken together, the results of this study both confirm prior research and establish new relationships when examining children's academic success in schools. Not only is achievement

associated with cardio-respiratory fitness, but we have learned that predictors of cardio-respiratory fitness function in different ways for males and females. Further, there are multiple proximal outcomes on the way to greater health and achievement that can be influenced through intervention. There are also important sex differences that must be considered in any intervention effort. As schools and teachers continue to strive to maximize youth achievement, considerations of the whole-child must take place. Understanding influences on achievement across multiple disciplines allows researchers and practitioners to have a holistic view of achievement and take into consideration specific combinations of factors that might not have been considered in the past.

Human Subjects Approval Statement

After IRB approval, parental consent and student assent was obtained.

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Table 1. Correlations and Descriptive Statistics

Males (n = 343)																		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**M**	**SE**
1. Age		.08	.11*	-.02	.07	-.03	-.04	-.05	.04	-.07	-.01	-.05	-.01	-.01	-.17	-.02	9.96	.02
2. Principal S.S.	-.07		.39**	.16**	.14*	.21**	.10	.13*	.18**	.08	.10	-.06	.03	-.01	-.07	-.11*	2.50	.06
3. Teacher S.S.	-.11*	.21**		.26**	.29**	.25**	.15**	.08	.25**	.07	.22**	.06	.16**	-.01	-.05	-.05	2.88	.05
4. Classmate S.S.	.02	.05	.16**		.42**	.37**	.20**	.07	.31**	.21**	.37**	.22**	.14**	.10	.12*	.16*	3.16	.05
5. Caregiver S.S.	-.05	.16**	.30**	.37**		.43**	.26**	.14**	.24**	.24**	.49**	.18**	.17**	.10	.10	.10	3.85	.05
6. PA Enjoyment	.04	.20**	.16**	.27**	.39**		.41**	.28**	.39**	.43**	.50**	.21**	.12*	.01	.17**	.15**	4.28	.03
7. Health Self-Concept	.09	.08	.13**	.20**	.27**	.33**		.21**	.27**	.50**	.40**	.26**	.12*	.09	.04	.10	4.53	.06
8. Nutrition S.E. & Att.	.07	.04	.18**	.27**	.30**	.44**	.26**		.33**	.18**	.15**	.04	.20**	.27**	.11*	.12*	4.01	.03
9. School Attachment	-.03	.13*	.14**	.24**	.23**	.34**	.18*	.36**		.32**	.21**	.14**	.10	-.02	.14**	.12*	3.98	.04
10. Global Self Esteem	.11*	.01	.04	.09	.22**	.33**	.50**	.28**	.33**		.27**	.18**	.12*	.09	.16**	.15**	5.16	.05
11. Subjective PA	.12*	.12*	.16*	.31**	.35**	.51**	.39**	.37**	.21**	.30**		.28**	.19**	.12*	.04	.07	**3.49**	.04
12. PACER	-.03	-.06	.01	.18**	.16**	.21**	.12*	.12*	.19**	.12*	.21**		.05	.05	.16**	.29**	**18.31**	.60
13. Fruit Consumption	.01	.02	.01	.09	.21**	.16**	.07	.25**	.13*	.11*	.26**	.16**		.46**	.09	.07	2.12	.11
14. Veg. Consumption	.01	.01	.11*	.12*	.16**	.17**	.08	.33**	.07	.10	.15**	.15**	.34**		.13*	.13*	1.70	.11
15. DIBELS (Reading)	-.04	-.12*	-.08	.05	.04	.03	-.03	.10	.11*	.09	-.07	.24**	.13*	.08		.55**	18.85	.42
16. AIMSweb (Math)	-.03	-.05	-.01	.17**	.10	.08	-.05	.05	.13*	.05	-.06	.23**	.08	.15**	.46**		24.14	1.03
Mean	9.95	2.72	2.95	2.93	3.77	4.22	4.77	4.09	4.10	5.12	**3.18**	**14.44**	2.24	2.00	20.41	20.78		
Standard Error	.02	.05	.05	.05	.05	.03	.06	.02	.04	.05	.04	.39	.10	.11	.46	.87		
Females (n = 354)																		

Note. Significant correlations are designated with asterisks (* $p < .05$; ** $p < .01$). Significant moderation by sex for means are bold ($p < .001$).

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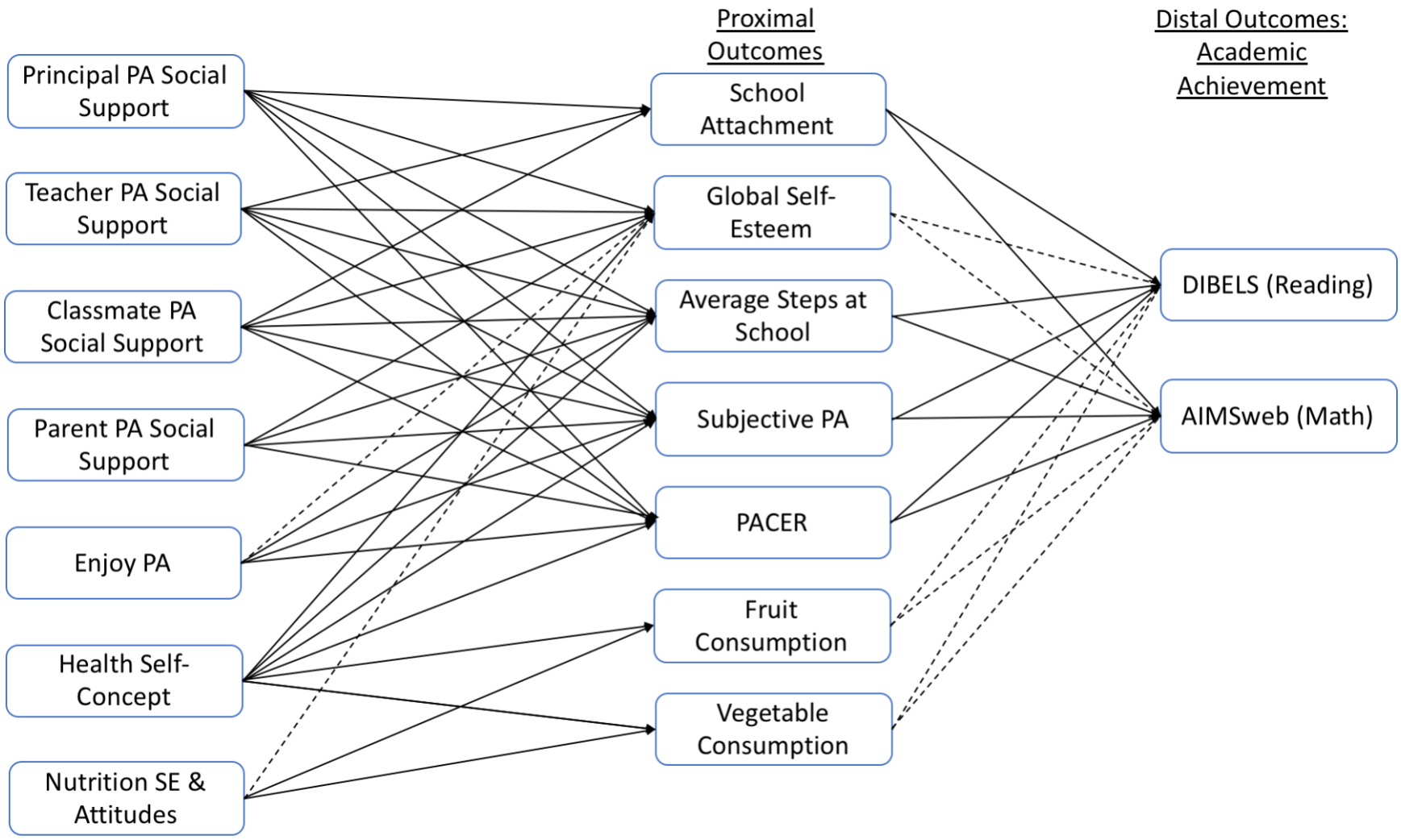
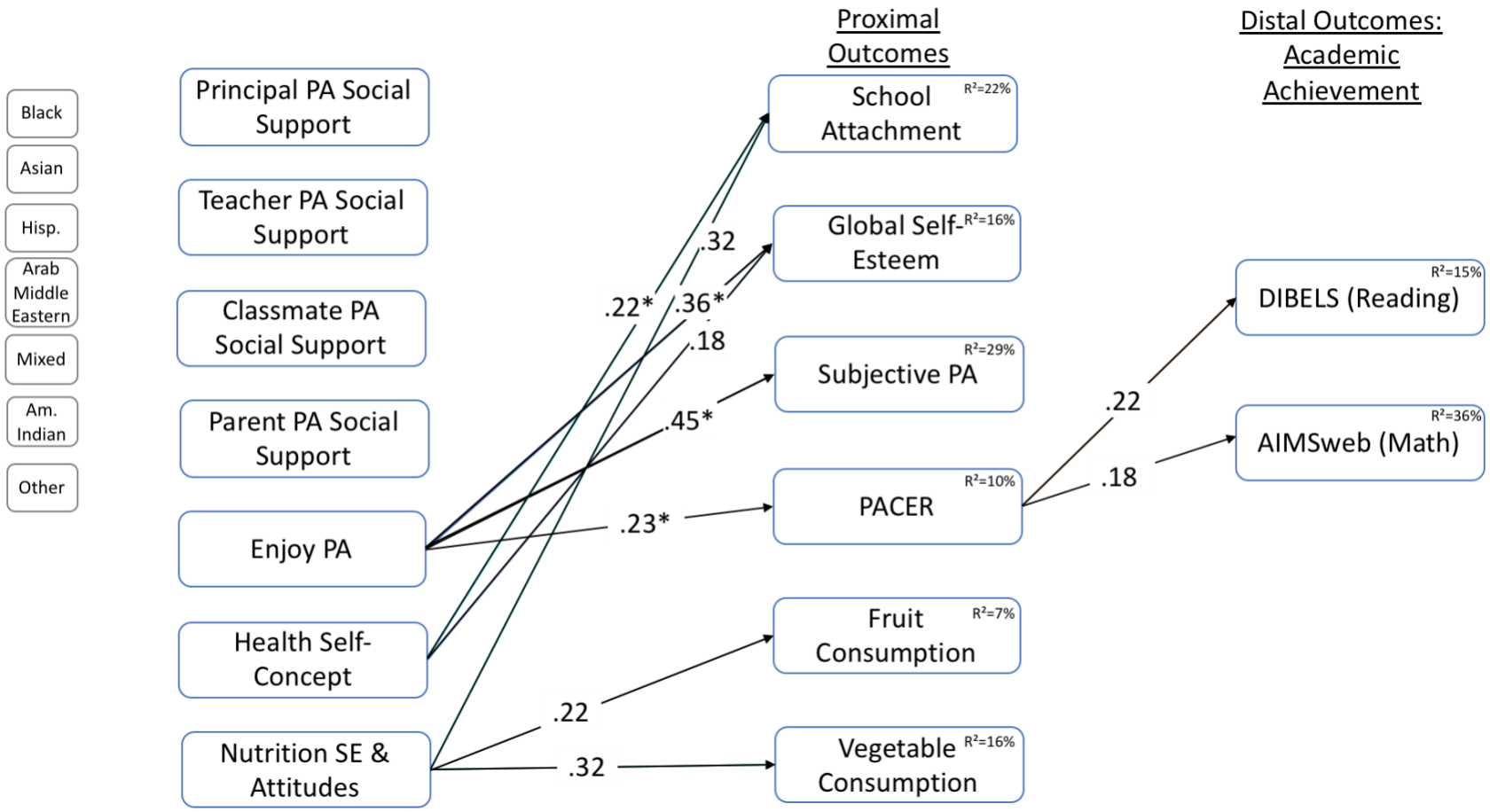
Figure 1. Hypothesized Significant Regression Path Analysis Model



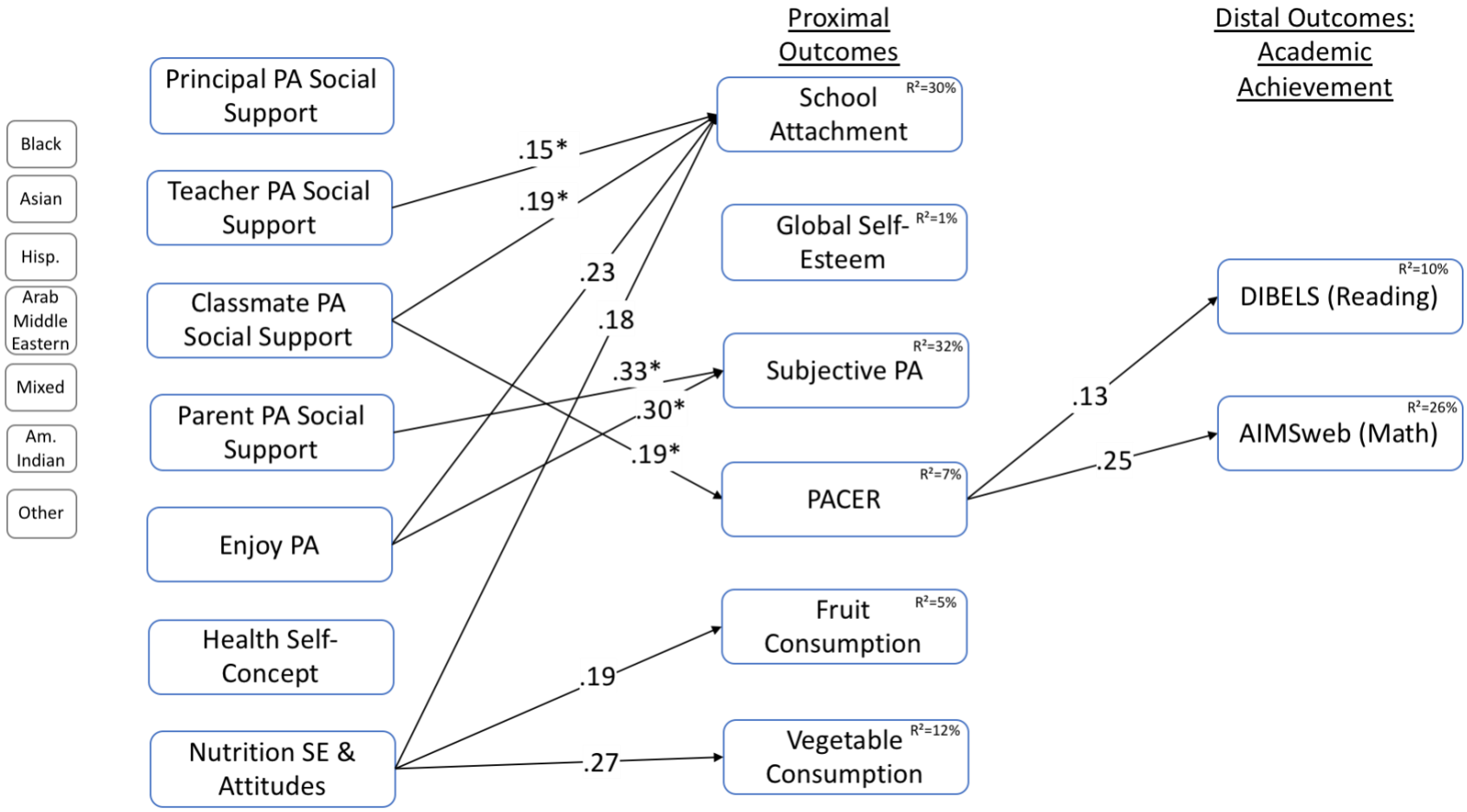
Note. Solid lines were hypothesized to be significant. Dashed lines were additional, alternative hypothesized regression coefficients.

Figure 2. Model of Female Students' Academic Achievement Predictors



Note. All constructs were correlated within their category, and regressed upon their reported race (Caucasian was the reference group). All paths shown are standardized regression coefficient values that are significant at the $p < .001$ level. Regression coefficients with asterisks are significantly moderated by sex ($p < .001$).

Figure 3. Model of Male Students' Academic Achievement Predictors



Note. All constructs were correlated within their category, and regressed upon their reported race (Caucasian was the reference group). This final model fit for the two-group model was $\chi^2_{115} = 228.021$, CFI = .993, NNFI = .966, SRMR = .04, RMSEA = .053. All paths shown are standardized regression coefficient values that are significant at the $p < .001$ level. Regression coefficients with asterisks are significantly moderated by sex ($p < .001$).