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The Relationship of Physical Activity Participation on Executive Functions and Stress Regulation Among Youth in Poverty

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Individuals living in poverty are exposed to greater amounts of adversity, potentially resulting in greater levels of circulating stress hormones. Elevated levels of stress hormones are associated with impaired brain development and executive functions. Deficits in executive functions can result in detrimental education and life outcomes among school-aged youth. Conversely, physical activity has been shown to improve executive functions among youth. Therefore, the purpose of this study was to examine if physical activity is related to greater executive functions and stress regulation among youth in poverty. In order to assess these relationships, executive functions (cognitive flexibility, inhibition, & working memory), salivary cortisol, physical activity, health-related quality of life, and school climate were measured among participants (N = 149) in the 5th-8th grade from three schools located in districts of poverty in the northeast and the southwest of the United States. The results revealed statistically significant differences in working memory among more active youth in poverty compared to less active youth, but no statistically significant differences in cognitive flexibility or inhibition ($p < 0.05$). Additionally, the results also showed no statistically significant differences in morning or afternoon salivary cortisol among more active youth, when compared with less active youth ($p > 0.05$). However, active youth had significantly different changes from their morning to afternoon salivary cortisol compared to less active youth ($p < 0.05$). These findings support previous research that shows how physical activity is associated with greater executive functions and stress regulation, which has implications for health, education and life outcomes, particularly among youth in poverty.

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Romans 11:36 “Because out from Him and through Him and to Him are all things. To Him be the glory forever. Amen.”

My wonderful wife: We did it mi amor! Thank you for being my spiritual companion, teammate, encouragement, joy and love throughout this arduous journey. I could not have done this without your support. Thank you for all of the sacrifices you have made during these past 6 years as a wife, and mother. I wouldn’t want to go through this adventure with anyone else! On to another one! I love you more every day.

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According to the United States Census Bureau, approximately 43.1 million individuals were living in poverty in the United States in 2015, or approximately 13.5% of the United States population (Proctor, Semega & Kollar, 2016). The U.S Census Bureau defines the poverty threshold by examining the annual income and the size of the family. For a family of two, under the age of 65, the poverty threshold is $16,151 and the annual income of a family of three, under the age of 65 is $19,105. The poverty threshold continues to increase in $5000.00 increments for each additional person added to the household. A disparate amount of Black (22%) and Hispanic (19.4%) families are currently living in poverty in the United States, compared to non-Hispanic Whites (8.8%) (Semega, Fontenot & Kollar, 2017). The disparity can be attributed to the historical and current systemic oppression that these racial and ethnic groups have experienced in the United States (e.g. slavery, Jim Crow, zero-tolerance immigration).

Race and ethnicity are widely considered a crucial social determinant of health, due to its association with poverty, discrimination, residential segregation, and unequal access to health care (Mehta, Lee, & Ylitalo, 2013; Williams, & Jackson, 2005). Living in poverty is strongly associated with a plethora of factors that negatively impact mental and physical well-being (Rafael, 2011;Mehta et al., 2013;Walker & Druss, 2016). Cumulative exposure to adversity (e.g. abuse, violence, neglect) including experiencing socioeconomic disadvantage during childhood is related to the many leading causes of death among adults (Felitti, et al., 1998), and is predictive of age-related disease risks (Danese et al., 2009).

Furthermore, disproportionate exposure to adverse childhood experiences occurs among individuals living in poverty compared to their more economically advantaged counterparts (Evans, 2004; Steele, et al., 2016). Due to the chronic, elevated levels of stress hormones, individuals living in poverty are at a higher risk for numerous diseases including heart disease, diabetes and hypertension (Lai, Alfaifi, Althemery, 2016; Shonkoff & Garner, 2012). Experiencing poverty early on in life through material and nutritional deprivation, as well as exposure to chronic stress and environmental toxins (such as neglect and air pollution), can lead to lifelong impairments in learning, behavior and health (Johnson, Riis & Noble, 2015; Shonkoff et al., 2012).

Brain development and function of individuals living in poverty are negatively affected, compared to more affluent peers (Hanson et al., 2012; Johnson et al., 2015; Shonkoff, et al., 2012). Specifically, the areas of the brain that are predominately affected include the prefrontal cortex and the hippocampus, which are associated with higher-level thinking, executive functions and memory (Hair, Hanson, Wolfe, & Pollak, 2015; Hanson et al., 2012). Studies also show that individuals who have experienced trauma or damage to their prefrontal cortex have an impaired ability to govern their behavior and impulses and lack the understanding of the consequences of their behavior (Ackerman, Brown, & Izard, 2004; Garret, 2009).

The brain regions (i.e., the prefrontal cortex and the hippocampus) and their optimal functions are critical to the success of any child attending school. The prefrontal cortex is directly involved with planning, organizing, impulse control, and some forms of decision-making (Garret, 2009). The prefrontal cortex also plays a crucial role in emotional regulation including the restraining of aggression, adjusting behavior in response to rewards and punishments, and the moderating of other behaviors (Garret, 2009). The prefrontal cortex also plays a major role in working memory and functions as a temporary memory register. Moreover, the prefrontal cortex is primarily responsible for executive functions, which include working memory, inhibition and cognitive flexibility (Diamond, 2013). Improving executive functions has positive implications for students, which may help them resist distractions to maintain focus (inhibition), retain and manipulate information (working memory) and have the ability to respond appropriately to novel, and challenging, situations (cognitive flexibility) like those generational poverty inflicts (Diamond, 2013; Hillman et al., 2014).

Participating in sports and physical activity has been shown not only to be of benefit physically, socially, and emotionally, but also cognitively. Even though there is an ongoing debate regarding what constitutes an activity from being a sport, in this study sport is operationally defined as an activity that includes the components of play, formal organization, formal competition, skill (not chance), physical skills, have a broad following and have achieved institutional stability where social institutions have rules which regulate it (Guttman, 1978; Jenny, Manning, Keiper, & Olrich, 2017; Suits, 2007). Perkins and Noam (2007) discussed how positive youth development takes place through the medium of thoughtful, well-designed sport programs, coining the term "sports-based youth development." Research has revealed how the social competencies of respect, caring for others, self-discipline, and personal and social responsibility have been developed through sport participation within physical education classes, community and school sport, and local club teams (Hellison, 2011; Papacharisis, Goudas, Danish & Theodorakis, 2005; Whitley, Hayden & Gould, 2015).

Participating in sport and physical activity has also been shown to increase muscular strength, endurance (Smith et al., 2014), and positively impact cardiorespiratory fitness (Schaefer et al., 2014). Physical activity is operationally defined in this study as activities that also includes components of play, skills (not chance), physical skills, yet lack the components of formal organization and formal competition (Guttman, 1978; Jenny, Manning, Keiper, & Olrich, 2017; Suits, 2007). Examples of physical activities include pick-up games of sports, skipping, running, tag games, catch, exercising and bicycling. Recent studies examining the impact of physical activities on brain function have been promising. Moderate aerobic exercise has been shown to improve aspects of executive functions and memory among predominately Caucasian, middle class older adults (> 65 years) (Chaddock et al., 2010, Colcombe et al., 2006; Erickson et al., 2011). Meanwhile, participation in a physically active after school program has also shown improvements in executive functions among school-aged children (8-9 years old) (Hillman et al., 2014).

Problem Statement

Despite the promising research on the impact of physical activity on executive functions, there is a paucity of research that specifically examines this impact among youth living in poverty. Poverty is associated with greater exposure to adverse experiences, which may elevate resting stress hormone levels and lead to a plethora of negative outcomes, both physically and cognitively. It is worthwhile to examine if participation in physical activities in high poverty districts may act as a buffer to the harmful effects of living in poverty on stress regulation and executive functions. Studying the impact of physical activity on executive functions in populations living in high poverty is important for several reasons**:** (a) Improved executive functions and stress regulation can lead to a cascade of positive behavioral, emotional and academic effects; (b) Outcomes can inform education policy makers, school administrators and community stakeholders to advocate for more structured physical activity times during and after school hours to improve school and life outcomes; and (c) Physical activity can then be used as an intervention to mitigate the negative effects of poverty on brain function (i.e., executive functions) and stress regulation. Therefore, the purpose of this study was to explore the relationship of physical activity participation on executive functions and stress regulation among youth living in poverty.

Conceptual Framework: Bronfenbrenner's Bioecological Systems Theory

According to Bronfenbrenner's bioecological systems theory (Bronfenbrenner, 1979; Bronfenbrenner, 1989; Bronfenbrenner & Ceci, 1994; Bronfenbrenner, 2005) social context affects an individuals' development, health and well-being. Human development occurs through consistent interactions of individuals with their environments and social contexts over time (Bronfenbrenner & Ceci, 1994). Social contexts are structured into five areas: 1) Microsystem—where the individual participates directly, such as the family unit, school and community environment. 2) Mesosystem—where members from different microsystems interact with each other independent of the central individual, such as the linkages between school and home. 3) Exosystem—entities and organizations that might be accessed by the individual or their family, such as parents' workplaces and extended family members. 4) Macrosystem—politics, views and customs that represent the cultural fabric of the individuals' society, such as cities, states and countries that are governed by a set of political beliefs. Lastly, 5) Chronosystem—or time as it relates to events that span across all contexts (Bronfenbrenner, 1977; Bronfenbrenner & Morris, 2006) (See figure 1).

An examination of a child's physical activity is a clear example that demonstrates how the macrosystem, exosystem, mesosytem and microsystem interact on an individual. Within the microsystem families are major actors that interact directly with the individual. The physical activities the family chooses to support and participate in, are the activities that the child engages in, which can impact cognitive and health outcomes. Yet what governs the accessibility of physical activity opportunities of the family depends on a variety of factors. In the mesosystem, families interact with schools and neighbors and may have access to various sport (school sponsored) and physical activities (playground) from these actors, which helps determine the physical activities of the child. Within the exosystem, families may also interact with local community services and recreation centers like a local Young Men's Christian Association (YMCA) or Police Athletic League (PAL) that also influences the sport and physical activity opportunities of the family. Lastly, in the macrosystem the culture and customs of a family, which can also be governed by ethnicity and race, and the influences of sport media can play a large role in the type sport and physical activities that a child participates in. If a child is only exposed to racially similar sport figures that only participate in a certain sport, then this may also play a role in determining participation. This simple example reveals how the sport and physical activity choices of a child is not determined on their own, but is a complex interaction between all of these social systems.

Various interactions between an individual with different actors within the microsystem influences the overall development of a person. The direct or indirect exposure to various experiences within the microsystem, causes an interaction with one's biology (genetic predispositions), impacting development, perceptions, responses and behaviors (Bronfenbrenner & Ceci, 1994; Shonkoff & Garner, 2012). These interactions between biology and ecology occur over the life span, beginning even as early as the womb (Marquez, Bjorke-Monsen, Teixeira, & Silverman, 2015). The human body also has a physiological response when it directly encounters various environmental stressors in the microsystem, issuing in the release of stress hormones, which then effect certain organs and tissues. What an individual deems as a stressor depends upon their life experience and how these experiences have shaped their perceptions of environmental stress. When this stress response is over activated for extended periods of time, due to environmental stressors, such as living in poverty during childhood, it can lead to negative health outcomes.

On the positive side, the human body also responds to participation in sport, and physical activity. In addition to the physiological response to the activity itself, the social context in which these activities are occurring may also be a factor that may deactivate the stress response, such as the presence of caring coaches and peer acceptance, or exacerbate the stress response (bullying, peer rejection). Examining all systems and all interactions that may affect the development of an individual, while important, is outside the scope of the current study. Therefore, this study was focused solely on the microsystem and interactions within the microsystem that potentially impact the individual and their cognitive development and stress regulation.

Utilizing an ecological human development framework to examine the effect of poverty and physical activity on executive functions and stress regulation is ideal. Nevertheless, Bronfenbrenner's ecological theory lacks the ability to fully explain an individuals' perceptions that may mediate stress responses and behaviors to environmental stimuli. Furthermore, Bronfenbrenner's theory is limited in explaining any hierarchy that may exist between individual and environmental factors, and the ability of those factors to affect physical activity participation, executive functions and stress regulation. Therefore, adapting an ecological framework of human development to elucidate the effect of the interactions between individuals within their various environments on physical activity participation, executive functions and stress regulation is warranted. Subsequently, an adapted physical activity ecological framework that addresses these factors for this study was developed and utilized (See figure 2).

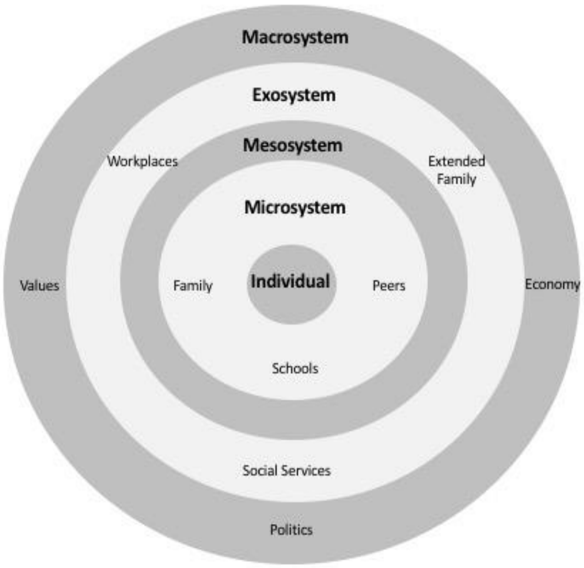


Figure 1. Bronfenbrenner's Ecological Systems Theory

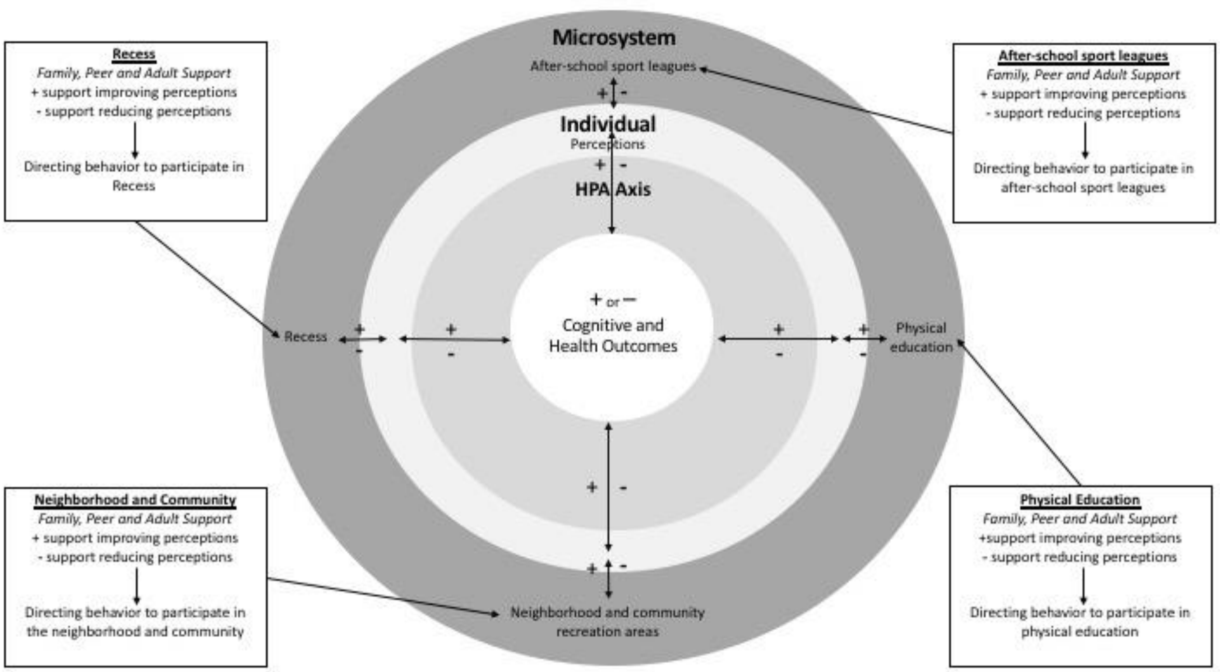


Figure 2. Adapted Physical Activity Ecological Framework

Research Questions

The research questions for this study are as follows. Among youth living in poverty: (1) What is the relationship between youth perceptions of quality of life and stress? (2) Is there a relationship between youth perceptions of quality of life and physical activity participation? (3) What is the relationship between youth perceptions of quality of life and executive functions scores? (4) Is there a relationship between salivary cortisol levels (stress) and executive functions scores? (5) Is greater physical activity related to greater executive functions? (6) Is greater physical activity participation associated with enhanced stress regulation?

Literature Review

Adverse Childhood Experiences and Their Effect on Health

The detrimental effects of experiencing chronic stress can start as early as in the womb. Maternal stress has been linked with low birth weight (Olson, et al., 2010), over-activation of the Hypothalamic-Pituitary-Adrenal (HPA) axis in the offspring (Lupien, et al., 2009), delayed hippocampal growth (Qui et al., 2013), and negative effects on cognition and language functions (Laplante, et al., 2008). Research also suggests that a harsh family climate in early life plays a role in people's susceptibility to chronic diseases later in life (Shonkoff, Boyce & McEwen, 2009). Children who are exposed to childhood maltreatment, social isolation, adverse childhood experiences and low SES have increased age-related-disease risks in adulthood (Danese & Moffitt, 2009). Another study revealed the strong relationship between exposure to adverse childhood experiences and the greater probability of lifetime and recent depressive disorders (Chapman, Whitfield, Felitti, Dube, Edwards & Anda, 2004). A study by Remigio-Baker et al., (2014) found that experiencing verbal abuse during childhood had the strongest magnitude of association (Odds Ratio = 3.21, CI = 2.03-5.09) to current depressive symptoms among women in Hawaii (Remigio-Baker et al., 2014).

The seminal Adverse Childhood Experiences Study (ACEs) developed by Felitti, Anda, Nordenberg, Williamson, Spitz, Edwards, Koss, and Marks (1998) linked childhood experiences of neglect, abuse and household dysfunction with negative health outcomes in adulthood. The authors surveyed over 17,000 Kaiser Health Plan members over two years and discovered a dose-dependent relationship between adverse childhood experiences and at-risk behaviors in adulthood. A dose-dependent relationship means that as the number of adverse childhood experiences increased, there was a concurrent increase in negative health outcomes such as: increase in risk-taking behaviors, chronic illness, and early death (Felitti et al., 1998). Through their study, the authors developed an ACE score system which represented the cumulative burden of childhood adversity experienced, with each experience counting as one point on the score system. The authors found a dose-dependent relationship even after adjusting for demographics and higher ACE scores were linked to early mortality related to cardiovascular, pulmonary, and liver disease (Felitti et al., 1998).

Studies have also shown how childhood stress and adversity is related to chronic disease (cancer, autoimmune disease, liver disease) and health risk behaviors such as alcohol and drug abuse (Brown, Thacker & Cohen, 2013; Dong et al., 2003; Dube et al, 2009, Strine et al., 2006). Utilizing the Behavioral Risk Factor Surveillance System (BRFSS) nationwide survey, Brown et al., (2013) reported the sexual abuse variable to be significantly related with the onset of adulthood cancer (OR: 1.21; 95% CI: 1.03-1.43). Dube et al. (2009) examined the relationship between cumulative childhood stress and autoimmune disease in adults and found a dose-dependent relationship with childhood traumatic stress increasing the likelihood of being diagnosed with an autoimmune disease in adulthood. Individuals with two or more adverse childhood experiences were at a 70% increased risk of idiopathic myocarditis, 80% increased risk for myasthenia gravis, and 100% increase risk for rheumatic diseases ($p < 0.05$).

Another study by Dube and colleagues (2002) elucidated the relationship between adverse childhood experiences and personal alcohol abuse as an adult. The authors reported that each of the eight adverse childhood experiences were associated with a higher risk of alcohol abuse as an adult. Furthermore, adults with at least four adverse childhood experiences had twice the likelihood of reporting heavy drinking and three times the likelihood of reporting alcohol problems in adulthood, when compared with adults with no ACEs. The highest risk of heavy drinking (24.2%) and self-reported alcohol problems (30.7%) was observed among adults with four or more reported adverse childhood experiences and a history of parental alcoholism (Dube et al., 2002).

Stressors that are capable of inducing chronic, high levels of stress include child abuse, neglect, and parental substance abuse, which have been found to be more common with children living in poverty (Felitti et al., 1998). Individuals from lower SES report more exposure to stressful life events and greater impact of these events than individuals from higher SES (Lupien, et al., 2001). A study examining the impact of adverse childhood experiences (ACEs) on an urban pediatric population ($N = 701$) found the majority of subjects (67.2%) had experienced one or more categories of adverse childhood experiences, with 12% experiencing four or more ACEs (Burke, Hellman, Scott, Weems, & Carrion, 2011).

Childhood adversity is also related to critical academic and social outcomes. Metzler, Merrick, Klevens, Ports, and Ford (2016) analyzed data from 10 states to examine the relationship between ACEs and adult education, employment and income and found that those with higher ACE scores were more likely to report unemployment, non-completion of high school, and living in a household below the federal poverty level. This result aligns with a report from the Centers for Disease Control and Prevention (2010) indicating a higher percentage of adults (14.9%) with greater than five adverse childhood experiences, having less than a high school education, compared to those who received a high school diploma or beyond (8.7% and 7.7% respectively). These reports show how early childhood exposure to adversity has a lasting effect on academic and socioeconomic outcomes.

Adverse Childhood Experiences and Their Effect on Brain Development and Function

Experiencing traumatic events and living in poverty as a child also has a negative impact on brain development and function. In 2015, Hair, Hanson, Wolfe, and Pollak (2015) examined data from the National Magnetic Resonance Imaging Study of Normal Brain Development and sampled 433 children aged 4 to 18 from across the U.S, from various socio-economic statuses (SES). Children from low SES groups displayed systematic structural differences in the frontal lobe, temporal lobe, and the hippocampus when compared to their peers from higher SES groups (Hair, Hanson, Wolfe, & Pollak, 2015). The regional gray matter volumes of children 1.5 time below the federal poverty level were, on average, three to four percentage points below developmental norms for their age and sex (Hair, Hanson, Wolfe, & Pollak, 2015).

Hanson et al. (2015) sought to assess the relationship between early life stress (i.e., physical abuse, neglect, and low socioeconomic status) and hippocampal and amygdala development. The authors reported smaller amygdala volumes for children exposed to all three forms of early life stress, and smaller hippocampal volumes for children who were physically abused or were from low socioeconomic status households (Hanson, et al., 2015). Noble et al. (2015) examined the relationships between socioeconomic factors (family income and parental education) and brain structure among children and adolescents. Among 1099 individuals between the ages of 3 to 20 years, the authors found that children from lower income families had significantly less brain surface area related to supporting language, reading, executive functions and spatial skills, than their higher SES counterparts (Noble et al., 2015). Carrion, Weems, and Reiss (2007) also examined the changes in hippocampus volume among children who have been exposed to trauma and found elevated pre-bedtime cortisol levels to be predictive of greater reductions in hippocampal volume.

While the seminal study by Felitti and colleagues (1998) established the link between adverse childhood experiences and adult health outcomes, the participants in the study were adults who grew up in the 1950s and 1960s were predominately white. Finkelhor, Shattuck, Turner, and Hamby (2015) and Wade et al. (2016), expanded the adverse childhood experiences scale to more accurately represent the level of adversity experienced across various socio-demographic identities, particularly among historically marginalized populations and those from lower SES groups. The additional measures of peer victimization, peer isolation/rejection, and community violence exposure added significantly to the prediction of mental health symptoms and the addition of a measure of low SES added significantly to the prediction of physical health problems.

Exposure to adverse experiences as a child has a clear relationship to negative adult health outcomes and behaviors, reinforcing the principle of Bronfenbrenner’s theory and the effects that a persons’ ecology has on cognitive development throughout the lifespan. With the clear relationship of adverse childhood experiences to negative health outcomes and brain development and function, it is worthwhile to examine the underlying biological response of stress and how its over-activity or dysregulation contributes to these detrimental health states.

Biological Stress Response: Hypothalamic-Pituitary-Adrenal Axis

The human body has a specific physiological response when it encounters circumstances that are perceived as a threat, such as adverse childhood experiences. Exposure to adverse childhood experiences within a household, community or school, such as witnessing violence in the community or being physically abused, activates this physiological response. Whether an individual deems a certain situation as a threat depends on one's own experiences, genetics and behavior (McEwen, 1998). When a threat is perceived, the body initiates a stress response, activating the hypothalamic pituitary adrenal (HPA) axis and mediating the release of the stress hormone cortisol (McEwen, 1998; McEwen, 2008). Although cortisol has short-term protective factors to the human body, excess amounts of cortisol over a longer period of time can be damaging to the multiple systems of the body and lead to future disease states (McEwen, 2012; Selye, 1936). Peak concentrations of cortisol are present during the first 30 minutes of wakeup (cortisol awakening response) and decline throughout the day with lowest levels occurring before bedtime (Bai, Robles, Reynolds, & Repetti, 2017).

Some studies have reported differences of cortisol levels among the sexes and related to pubertal status, but the results have been inconsistent. Schiefelbein, and Susman (2006) reported subtle sex differences among youth in the regulation of cortisol, with females showing higher basal levels of cortisol and higher levels among females in the later stages of puberty. Netherton, Goodyer, Tamplin, and Herbert (2004) also reported 20-30% greater morning cortisol levels in post-pubertal girls compared to post-pubertal boys, with no sex differences in pre-pubertal children. However, earlier studies by Knutsson et al. (1997) and Kerrigan et al. (1993) showed no effect of sex or pubertal stage on cortisol regulation. A more recent study by Stroud, Papadonatos, Williamson, and Dahl (2011) revealed differences among boys and girls with girls showing increased cortisol output over puberty, with boys showing no significant changes over puberty. Moreover, girls also exhibited increasing baseline cortisol over puberty, while boys showed declining baseline cortisol over puberty (Stroud et al., 2011). Age and pubertal maturation have also affected school-aged children and adolescents, with basal cortisol levels gradually increasing with age and pubertal maturation (Barra, Silva, Rodrigues, Santos & Colosimo, 2015; Kiess, Meidert, Dressendorfer, Scheiver, Kessler, & Konig, 1995; Lupien, King, Meaney, & McEwen, 2001). There appear to be subtle differences of HPA axis activity between sexes, maturation status, and age that may mediate the fluctuation of cortisol levels.

Activation of the HPA axis causes neurons in the hypothalamus to release a hormone called corticotropin-releasing hormone (CRH), which subsequently triggers the release of adrenocorticotropin (ACTH) from the pituitary gland (Lupien et al., 2007). ACTH then travels from the pituitary gland in the blood to reach the adrenal glands, which triggers the release of stress hormones, which are known as glucocorticoids (cortisol) and catecholamines (epinephrine and norepinephrine) (Lupien, et al., 2007). Cortisol alters the structure and function of a variety of cells and tissues as a way to protect the body from the perceived threat. Nevertheless, prolonged activation of the HPA axis and the exposure to excess amounts of cortisol can be detrimental to the body, limiting tissue repair and suppressing immune function. When the perceived threat is past, this response is deactivated and cortisol returns to baseline levels. Sterling and Eyer (1988) first introduced the term “allostasis,” which describes the process where the body responds to various events and achieves stability through change in order to maintain homeostasis.

However, there are instances where the normal stress response is dysregulated, resulting in an overexposure to cortisol and other stress mediators. In his seminal article, Hans Selye

(1955) formed a theory linking a dysregulated stress response to disease states. Overexposure to stress hormones for extended periods of time has been linked to lifelong detrimental effects on multiple systems in the body including the cardiovascular, metabolic, and immune, and the brain itself (Bosma, Marmot, Hemingway, Nicholson, Brunner, & Stansfeld, 1997; McEwen, 1998; Shonkoff & Garner, 2012). Cortisol also raises blood pressure, thus increasing the risk of developing hypertension and arterial disease (Lupien, et al., 2007). In a study examining workplace stress and disease states, Bosma et al. (1997) reported that the stress associated with the lack of control on the job increases the risk of coronary heart disease. Chronic stress has also been shown to suppress or dysregulate immune function. Cohen, Janicki-Deverts, Doyle, Miller, Frank, Rabin, and Turner (2012) reported that subjects with recent exposure to chronic stress were at a higher risk of subsequently developing a cold when exposed to the cold virus than subjects who had not recently experienced chronic stress.

McEwen (1998) referred to the chronic overexposure of stress hormones through repeated stressors or dysregulation of allostasis and their negative impact on the body's systems as *allostatic load*. The dysregulation of allostasis also includes not deactivating the stress response when it is no longer needed, not turning on an adequate response when needed, and the lack of adaptation to the recurrence of the same stressor (McEwen, 1998; McEwen, 2008). This dysregulation of allostasis and the resulting overexposure of stress hormones have a significant impact on physical and mental health (McEwen, 1998; Shonkoff & Garner, 2012). Specifically, studies have shown how chronic stress negatively impacts brain development and function (Danese & McEwen, 2012; Hillman, Khan & Kao, 2015, Lupien, Maheu, Tu, Fiocco, & Schramek, 2007; McEwen, 2012). Farah (2006) reported that low SES children were more likely to be deficient in language skills, memory, and self-regulatory skills that are associated with prefrontal and temporal lobes. Moreover, low SES is associated with a reduction in prefrontal cortical gray matter (Gianaros, et al., 2008). The underlying biological mechanisms causing attenuated brain development and function will be reviewed in the following section.

Impact of Chronic Stress on Brain Development and Function

Exposure to chronic stress throughout the lifespan can lead to permanent changes in brain structure and function (McEwen, 2005; Shonkoff & Garner 2012). How stress induces morphological changes with the brain lies with the underlying physiological processes that occur when the HPA axis is triggered. Excess amounts of cortisol change the structure of neurons, suppress neurogenesis, and cause the retraction and simplification of dendrites in the CA3 region of the hippocampus (McEwen, 2008; Sousa et al., 2000). As with all physiological phenomena, excess cortisol is not the sole factor affecting changes in the brain, but involves complex interactions with other neurochemical systems and mediators such as serotonin, GABA, excitatory amino acids, NMDA, cytokines, and glutamate (McEwen, 2008). To review and expound upon all of these complex interactions is outside the scope of this study, yet is important to consider when exploring physiological phenomena. Furthermore, technology is limited with measuring all of these complex interactions simultaneously, yet the biomarker of cortisol and its effects on the body has a strong foundation in the scientific literature. Therefore, cortisol is the main biomarker of interest in this proposed experiment.

Three main areas of the brain (hippocampus, amygdala, and the frontal lobes) are mainly responsible for learning, memory, and emotional processing, contain glucocorticoid (cortisol) receptors. The circulating cortisol binds to these two receptor sub-types (type I and type II), which impair neural plasticity (Gunnar & Quevedo, 2007). The type I receptors are exclusively present in the limbic system (hippocampus, parahippocampal gyrus, entorhinal, insular cortices), whereas the type II receptors are distributed in the subcortical and cortical structures, with the majority of type II receptors located in the prefrontal cortex (Lupien et al., 2007). The location of the type I and type II receptors is important and helps explain why frequent exposure to stress impacts certain brain regions. This is particularly critical for the prefrontal cortex, since a high density of type II receptors are present in the frontal region (Lupien et al., 2007; Pechtel & Pizzagalli, 2009). During periods of high stress or circadian peaks of cortisol, which typically occurs upon awakening, type I receptors become saturated, and approximately 67-74% of type II receptors become occupied (Lupien et al., 2007; Pechtel & Pizzagalli, 2009). Whereas, at resting states, when cortisol is at its lowest levels, which typically occurs right before sleep, 90% of type I receptors are bound, and only 10% of type II receptors are saturated (Lupien et al., 2007; Pechtel & Pizzagalli, 2009).

Understanding the high density of glucocorticoid receptors present in these brain regions and the impact that cortisol has on neurogenesis, grants insight into how exposure to chronic stress impacts brain development. Exposure to toxic levels of stress is of particular significance during critical periods of brain development, whether it may be in the womb or during childhood, when important regions of the brain and its functions are still undergoing development. High levels of circulating cortisol and its contribution to attenuated development in these brain regions during these critical development periods can help explain deficits in brain volume and cognitive function among individuals who have experienced childhood adversity (Lupien et al., 2007; McEwen et al., 2012; Pechtel & Pizzagalli, 2009).

The developing brain is profoundly impacted by exposure to traumatic life events. And, exposure to chronic stress has been shown to dysregulate the normal stress response. Studies among adults show smaller hippocampal gray matter volumes were found in women who reported higher perceived stress scale scores over approximately 20 years, even after controlling for age and other potentially confounding variables (Gianaros, Jennings, Sheu, Greer, Kuller, & Matthews, 2006). Among children who experienced traumatic life events, a significant negative relationship [r (31) = -.43; p = 0.013] between increased bedtime cortisol, which should be at its lowest diurnal levels (0.93) and decreased left ventral prefrontal cortex gray volumes were found (Carrion et al., 2010). Another study that examined the psychological trauma of the World Trade Center attacks on September 11th, found adults with closer proximity to the terrorist attacks had lower gray matter volume in the hippocampus, insula, anterior cingulate, and medial prefrontal cortex (Ganzel, Kim, Glover & Temple, 2007). These studies show how chronic stress and traumatic events effect brain volume, which can also significantly impact cognitive function.

An ongoing debate remains regarding the relationship between volume and cognitive function, particularly with hippocampal volume and memory among young and older adults. Van Petten (2004) published a meta-analysis on the correlations between hippocampal volume and memory across the lifespan and reported a negative relationship between hippocampal volume and memory for children, adolescents, and young adults. Studies with older adults revealed a positive correlation between hippocampal volume and memory performance (van Petten, 2004). To explain this phenomenon, Lupien et al. (2007) suggests that there is an optimal volume of the hippocampus (3.86cc) for memory performance among young and older adults, which can be attributed to genetic and experiential factors.

Impact of Stress on Cognitive Function

Early life stress has been found to be associated with deficits in cognitive performance, memory, and executive functioning (Pechtel & Pizzagalli, 2011). Blair et al. (2011) conducted a 3-year longitudinal study among 1,292 children from birth and found higher levels of cortisol at ages 7, 15, and 24 months being related to lower executive functions and IQ at age 3. A recent study by Blair and Berry (2017) revealed that children with low average resting levels of cortisol between 7 and 48 months of age performed better on executive functions tests. In contrast, the authors reported that children with high average levels of cortisol tended to have lower performance on the battery of executive functions tasks (Blair & Berry, 2017).

Studies also reveal that there are positive and negative effects of cortisol, with an optimum level of cortisol contributing to enhanced cognitive function. De Kloet et al. (1999) suggested that circulating levels of cortisol and its relationship to memory performance operates as an inverted “U”. When circulating cortisol is significantly decreased (not enough cortisol) or significantly increased (too much cortisol), cognitive function is impaired. Whereas, when circulating cortisol occupies most of the type I receptors and only a small portion of type II receptors, cognitive function is enhanced (de Kloet et al., 1999). The findings of Lupien et al., (2002) supported the inverted U theory developed by de Koet et al. (1999). The authors performed a hormone removal-replacement study and found that a decrease in circulating levels of cortisol significantly impaired declarative memory by 8%, yet this impairment was completely reversed when cortisol was returned to normal levels (Lupien et al., 2002). In an earlier study conducted by Lupien, Gillin, and Hauger (1999) the authors observed detriments on memory when cortisol was injected into participants during the time of the circadian peak (which is upon awakening), reifying the theory that cognitive function declines when individuals are exposed to excess amounts of cortisol.

The majority of studies of stress on cognitive function in humans focus on children who have experience institutionalized care. For instance, children who spent the first portion of their life in institutionalized care revealed impaired intellectual performance compared to children who were never institutionalized (Loman, Wiik, Frenn, Pollak & Gunnar, 2009). In another study neglected children were compared with non-neglected children, and it was found neglected children scored significantly lower on an IQ test, memory/learning, and executive functioning (De Bellis, Hooper, Spratt & Wooley, 2009). Studies also reveal disrupted emotional processing, with the hyperactivity of the amygdala and hippocampus, among individuals who have experienced childhood adversity (Murasak, Martin, Etkin & Thomason, 2015). Overall, the findings from these studies indicate that individuals who have adverse childhood experiences possess deficits in the prefrontal cortex, hippocampus, and amygdala, which are responsible for memory, response inhibition, cognitive attention, and emotional processing. These key cognitive functions are necessary for learning and behavioral regulation, which are crucial skills related to academic outcomes and success.

Prefrontal Cortex and Executive Functions

The prefrontal cortex and its executive functions have received much attention within the literature due to the delayed onset of development during late adolescence and its strong relationship to academic and life outcomes. The prefrontal cortex is located in the anterior portion of the frontal lobes of the brain and plays a crucial role in the restraining of aggression, adjusting behavior in response to rewards and punishments, and the moderating of other behaviors (Garret, 2009). The prefrontal cortex also contributes to working memory, and functions as a temporary memory register and is critical in "top-down" processing, where behavior must be guided by internal states or intentions (Miller & Cohen, 2001). It is directly involved with planning, organizing, impulse control, some forms of decision-making, the ability to initiate and carry out new and goal-directed patterns of behavior, sustained attention, inhibitory control, sequencing tasks, planning, and active problem solving—which are referred to as executive functions (Garret, 2009; Siddiqui, Chatterjee, Kumar, Siddiqui & Goyal, 2008).

Executive functions specifically refer to a family of top-down mental processes that make it possible to meet novel challenges, resist temptations, stay focused, and to take time to think before acting (Diamond, 2013). There are three core executive functions, which are inhibition (behavioral and cognitive), working memory, and cognitive flexibility. These skills of executive function are essential for mental health, physical health, school readiness and success (Blair & Razza, 2007; Diamond, 2005; Miller, Barnes, Beaver, 2011).

Inhibition also known as inhibitory control, enables individuals to control one's attention, thoughts, behaviors, and emotions to do what is more appropriate or needed, rather than succumb to an internal predisposition or external lure (Diamond, 2013). The amount of inhibitory control present early in life is predictive of outcomes throughout life and into adulthood. Moffit, Arseneault, Belsky, Dickson, Hancox et al., (2011) followed 1000 children for 32 years and found that children who possessed better inhibitory control were more likely to still be in school as teenagers and less likely to engage in risky behaviors. Furthermore, the authors found that those with more inhibitory control as children had better physical and mental health as adults, earned more, were more law-abiding citizens, and were happier (Moffit et al., 2011).

Working memory is also a part of the core of executive functions, which involves holding information in mind and working with the information even though it is no longer perceptually present (Baddeley & Hitch, 1994; Diamond, 2013). Working memory is critical for making sense of language, mental math and mentally relating information to recognize relationships between ideas, items and concepts (Diamond, 2013). Working memory is also crucial for creativity and the ability to make connections between two seemingly unrelated things. The ability to hold information in the mind develops as early as 9-12 months, yet any mental manipulation exhibits a prolonged developmental progression (Bell & Cuevas, 2012; Cowan AuBuchon, Gilchrist, Ricker, & Saults, 2011).

Cognitive flexibility is the last to develop of the core of executive functions and actually builds upon inhibition and working memory (Diamond, 2011). Cognitive flexibility involves the ability to change perspectives, the ability to change the way one thinks about something, and to be flexible enough to adjust to changed demands or priorities (Diamond, 2011). Cognitive flexibility improves during child development and declines during aging (Cepeda, Kraemer, & Gonzalez de Sather, 2001).

The core executive functions (working memory, inhibition, cognitive flexibility) are related to academic achievement among school-aged children (Cameron et al., 2010; De Franchis, Usai, Viterbori & Traverso, 2017; Vandenbroucke, Verschueren & Baeyens, 2017; Willoughby, Kupersmidt, Voegler-Lee, & Bryant, 2011). At an early age, executive functions show associations with mathematics skills and language skills such as spelling and reading (Welsh, Nix, Blair, Bierman, & Nelson, 2010). Working memory was found to be a significant predictor of math achievement, learning biology, spelling performance and reading comprehension and achievement (De Franchis et al., 2017; Rhodes, Booth, Campbell, Blythe, Wheate & Delibegovic, 2014; Stevenson, Bergwerff, Heiser, & Resing, 2014; Vandenbroucke, et al., 2017). Cognitive flexibility has also been found to be related to conceptual and abstract mathematical skills, while inhibition has been associated with print knowledge, such as the directionality of print, letter names and sounds (Purpura, Schmitt, & Ganley, 2017). Developing these executive function skills among school-aged children are foundational for school readiness and academic success.

Due to the interactions that occur with an individual within their microsystem, negative situations and interactions have the ability to shape executive functions as a child develops. Executive functions have shown to become impaired when the body experiences stressful situations like sadness, loneliness, sleep deprivation, and even being physically unfit (Best, 2010; Diamond, 2011; Oaten & Cheng, 2005). Studies have also shown that individuals who have experienced trauma or damage to their prefrontal cortex have an impaired ability to govern their behavior and impulses, and lack the understanding of the consequences of their behavior (Garret, 2009). Another study by Blake, Pincus, and Buckner (1995) revealed decreased activity levels in the prefrontal cortex of murderers who had killed in a bout of rage, supporting the hypothesis that the prefrontal cortex is involved in the regulation of impulses. The deficits of executive functions can also be seen in the educational context. Researchers found that children from lower SES groups had lower performance in verbal and math problems and had reduced working memory and poorer executive functions (Farah et al., 2006; Jordan, 1994; Noble, Norman, & Farah, 2005). Hair et al. (2015) also reported that differences in the frontal and temporal lobes may help to explain as much as 15% to 20% of the achievement deficit among low-income children.

Executive functions have also been shown to differ depending on sex and age, with most sex differences being apparent by early adolescence. Specifically, testosterone has sex-specific associations with prefrontal-hippocampal structural covariance, related to lower executive functions only among boys (Nguyen et al., 2017). Conversely, during early childhood girls typically outperform boys in inhibitory control and attention tasks (Cuevas, Calkins & Bell, 2016; Gur et al., 2012). Executive functions have also shown to improve substantially throughout childhood, through adolescence and into early adulthood, since maturation of the prefrontal cortex is delayed relative to other brain regions (Gur et al., 2012; Lemaire & Lecacheur, 2011; Matsuzawa et al., 2001; Perrin et al., 2009).

The prefrontal cortex and its executive functions are vital to the health and well-being of individuals. Nevertheless, individuals from low SES are at-risk to be exposed to more adverse experiences during childhood, which impact the development of the prefrontal cortex and its executive functions. However, recent studies show how the brain displays plasticity and the resilience to overcome adverse experiences with the proper interventions. Liston, McEwen, and Casey (2009) assessed the role of stress on the brain and elucidated how one month of exposure to psychosocial stress resulted in disrupted connectivity within the prefrontal cortex. Nevertheless, an encouraging finding was that the disruption of connectivity was reversible after one month of reduced stress, revealing the plasticity of the brain and its ability to recover from chronic exposure to traumatic experiences. This finding also sheds insight into the primary characteristic of potential treatments and interventions aimed at mitigating the negative effects of stress on the brain, which is that they must be stress reducing, not stress inducing.

Additionally, the prefrontal cortex does not fully mature until late adolescence, providing exciting opportunities for practitioners and clinicians to mitigate the negative effects of poverty. Moreover, individuals who possess the poorest executive functions consistently gain the most from programs and interventions aimed at improving these skills (Diamond & Ling, 2016). One study by Blair, and Raver (2014) examined an executive functions computer intervention (Tools of the Mind) and found effect sizes for lower-income children to be as high as 0.8, compared to the effect sizes of more diverse children rarely surpassing 0.1. These encouraging findings grant hope into reducing and reversing the negative effects of adversity on the prefrontal cortex and its executive functions, which can have a cascade of positive impacts on academic and social outcomes. With executive functions being so critical to academic and life outcomes, a number of studies have examined executive function interventions and have shown promise in improving these executive function skills.

Interventions Improving Executive Functions

With the prefrontal cortex and executive functions exhibiting plasticity throughout the lifespan, targeted interventions hold promise to improving executive functions. An intervention that utilized a randomized controlled trial with children to train executive functions with a computer program found significant improvements in working memory, especially among children with lower working memory skills (Holmes & Gathercole, 2013). Furthermore, the authors found an association between improved working memory with greater progress in math and English (Holmes & Gathercole, 2013). Other studies utilizing computer programs to improve executive functions among children have had significant positive outcomes (Holmes, Gathercole, & Dunning, 2009; Karbach & Kray, 2009; Mackey, Hill, Stone, & Bunge, 2011).

Physical activity and exercise has also shown promise as an appropriate intervention to improve executive functions. Studies among the older adult population have found how low-to-moderate intensity aerobic exercise improves cognition and brain volume in the hippocampal and frontal regions (Colcombe et al., 2006; Erickson et al., 2009; Erickson et al., 2011). A unique study that used Tae Kwon Do to develop executive functions, found that after 3 months of participating in the intervention, the Tae Kwon Do group demonstrated greater improvements in cognitive self-regulation, affective self-regulation, prosocial behavior, classroom conduct, and in the performance on a mental math test than the control group (Lakes & Hoyt, 2004). Another study examined if exercise would improve cognitive function among 7 to 11-year-old overweight children and found dose-response benefits of exercise on executive functions and mathematics achievement (Davis et al., 2011). Chaya et al. (2012) also found yoga to improve executive functions skills over a physical training group in 20 girls, 7-9 years of age.

Hogan et al. (2015) examined 30 adolescents (ages 13-14) in an executive functioning task and found higher aerobically fit participants having significantly faster reaction times in the exercise condition, and lower error rates in the resting condition. Hillman et al. (2014) assessed the effect of a 9-month, aerobic physical activity afterschool program on brain and behavioral indices of executive function in 8-9-year olds. Participants who received the physical activity intervention demonstrated greater improvement in attentional inhibition (3.2%, 95% CI: 0.0 to 6.5, $d = 0.27$) and cognitive flexibility (4.8%, 95% CI: 1.1 to 8.4, $d = 0.35$) than the control group who did not receive the intervention. It is clear from the research that participating in various forms of physical activity and having a higher fitness status can be of benefit to executive functions.

While a few studies have examined the positive effects of physical activity and exercise on executive functions among youth, researchers have not studied this phenomenon among youth in poverty. With the potential lifelong effects of adverse childhood experiences and poverty on executive functions, along with its education implications, it is of upmost importance to assess whether physical activity participation is associated with improved executive functions, despite consistent exposure to adversity. Therefore the purpose of this study is to examine the relationships between physical activity participation on executive functions and stress regulation among youth in poverty.

Hypotheses

In order to examine the relationship between physical activity participation, executive functions and salivary cortisol, the following hypotheses were developed. Among youth living in poverty:

H_0 1: There is no relationship between the health-related quality of life survey and salivary cortisol levels.

H_a 1: Lower scores on the health-related quality of life survey will be negatively correlated with salivary cortisol levels.

H_0 2: There is no relationship between the health-related quality of life survey and greater physical activity participation.

H_a 2: Higher scores on the health-related quality of life survey will be positively correlated with greater physical activity participation.

H_0 3: There is no relationship between the health-related quality of life survey and cognitive flexibility, inhibition and working memory scores.

H_a 3: Higher scores on the health-related quality of life survey will be positively correlated with cognitive flexibility, inhibition and working memory scores.

H_0 4: There is no correlation between salivary cortisol levels and cognitive flexibility, inhibition and working memory scores.

H_a 4: Higher levels of salivary cortisol levels will be negatively related to cognitive flexibility, inhibition and working memory scores.

H_0 5: There are no statistically significant differences in cognitive flexibility, inhibition and working memory scores between youth who participate in more physical activity and those who participate in less physical activities.

H_a 5: Youth who engage in more physical activities will display greater cognitive flexibility, inhibition and working memory than those who participate in less physical activities.

H_0 6: There are no statistically significant differences in salivary cortisol levels between youth who engage in more physical activities and those who participate in physical activities.

H_a 6: Youth who engage in more physical activities will display lower salivary cortisol levels than those who participate in less physical activities.

Method

Participants

I recruited all students in the 5th-8th grade, who were enrolled in three separate K-8 schools (Schools A, B and C) that predominately served children in poverty (*N*= 149, School A = 71, School B = 39, School C = 39). To ensure an adequate sample of active and inactive participants among schools in poverty, three schools were chosen to participate in the study. One school was located in Arizona (school A), while two schools were located in Connecticut (schools B & C). School A was a charter school in Arizona, while schools B and C were located in Connecticut, and are both traditional neighborhood public schools. All three schools operated in districts where greater than 92% of the student body qualified for free/reduced lunch (school A = 96%, school B = 100%, school C = 92%). According to the income guidelines set by the U. S. Department of Agriculture, to qualify for free lunch the annual gross income of a family of two cannot exceed $21,112, placing these families' income around the poverty threshold.

Table 1

Participant Demographics

	Black	Latino/a	Other	% Free/reduced Lunch	*n*
School A	12%	85%	3%	96%	71
School B	36%	62%	2%	100%	39
School C	82%	17%	1%	92%	39

Setting

School A. Students enrolled in School A were given the opportunity to engage in approximately 45 minutes of physical education four days a week, for the entire duration of the academic year. Physical education in school A consisted predominately of muscular and aerobic exercise training designed by the coaches in the school, which included basic strength exercises such as push-ups and squats, and aerobic exercises such as sprints and long distance running. Coaches also incorporated speed and agility training into their physical education curriculum, which included plyometrics, ladder drills, and cone drills. Furthermore, students in school A were also provided the opportunity to participate in one school-sponsored sport (interscholastically or intramurally), 5-days a week, throughout the school year, comprising of a potential of an additional 120 minutes of sport participation a day. Examples of school-sponsored sport include basketball, football, volleyball and soccer.

Additionally, all students in School A were also provided an additional 45 minutes of recess, four days a week, for the entire school year. During recess, students were given the choice to freely participate in any physical activity and could also decide to be sedentary during the allotted recess time. Therefore, students in school A were offered the opportunity to engage in 90 minutes of in-school physical activity (45 minutes of physical education; 45 minutes of recess) four days a week and 120 minutes of after-school sport, five days a week.

Schools B and C. The two schools in Connecticut (schools B and C) were neighborhood public schools, with a traditional curriculum focusing on academic enrichment. Students in schools B and C were allotted 45-50 minutes of physical education classes two times per week. Physical education classes in schools B and C consisted primarily of recess-like activities, where students were given multiple options to participate in various sport and physical activities or could also decide to be sedentary. Students in schools B and C were also provided with very limited opportunities for school-sponsored sports available (only boys basketball). Moreover, only the 5th grade students in schools B and C were provided 15-20 minutes of recess per day for the duration of the school year, where students were given the choice to either participate or not participate in various physical activities. Students who chose not to participate in physical activities during recess were involved in activities such as sitting, drawing and talking with friends.

Recruitment

All students in the 5th-8th grade in schools A, B and C were recruited by the student investigator, through a brief 5-minute presentation of the research study. The student investigator was accompanied by a school staff member to present to each classroom in the 5th-8th grade in schools A, B and C. Each presentation included an overview of the purpose of the study, the study procedures and the distribution of parental permission forms to participate in the study. All students who returned a signed parental permission form were enrolled in the study.

Setting

School A. School A in Arizona was located in a large urban area, with approximately 23.1% of individuals living poverty (www.census.gov). Forty-one percent of the population identifies as Latino/a, 45% as White, and 6.6% African American. Approximately 80.7% of individuals living in this city had a high school diploma and 25% possessed a Bachelor's degree or higher (www.census.gov). The demographic of School A consisted of 85% Latino/a, 12% African American, and 3% Native American students. Furthermore, similar to schools B and C, school A also served families in poverty, with 96% of the students qualifying for free/reduced lunch. School A became an established public charter school in 1999. Lastly, Arizona has a 19.8% obesity rate among 10 to 17-year-old children, ranking it among the top 10 of elevated rates of childhood obesity (www.cdc.gov).

Schools B and C. Participants from schools B and C in Connecticut were from a major urban area with a 34.4% poverty rate compared to the national average of 14.8% (www.census.gov). The majority of the population consisted of people of color with 38.7% of the population identifying as Black and 43.4% of the population identifying as Latino/a. Additionally, the percentage of college graduates (Bachelor's or higher) living in the area was 15%, compared to the national average of 29.3%. The high school graduation rate was 70.3%, lower than the national average, which is at 86.3%. Childhood obesity (10-17-year-old) in Connecticut was at 15%, which is slightly below the national average of 17% (www.cdc.gov). Yet a report by the Center for Public Health and Health Policy (2012) found that 20% of preschoolers were obese, and 17% were overweight in the city where school B and C are located. School B was comprised of 62% Latino/a, 36% Black and 2% other students. The racial demographics of school C students was 82% Black, 17% Latino/a and 1% White. School B was established in 1960 and school C was established in 1927.

Design

In order to explore the associations between physical activity, salivary cortisol levels, executive functions, perceptions of quality of life and school climate among youth in poverty, this study utilized a cross-sectional design. Data were collected at one time point during the Spring of 2018. Since no prior data have explored these desired relationships among the demographics of interest, the cross-sectional design was ideal to grant more insight into these associations.

Procedure

The dependent measures for this study included executive functions test scores, salivary cortisol, the pediatric quality of life inventory (PedsQL 4.0), a pubertal maturation observational scale (PMOS), a physical activity questionnaire (PAQ-C) and the Georgia Brief School Climate Inventory (GaBSCI). In this investigation, data were gathered over four separate visitations during school hours under direct supervision of the student investigator. Only the PMOS and the morning saliva sample were completed by the parent/guardian and returned to the school. During visit one, individual participants completed the assent protocol with the student investigator with all participants who handed in a parental permission form. The assent protocol included reading through a prepared document, reviewing in detail, the purpose of the study, the study procedures, the risks of the study, and the rights of the participants. All participants granted their assent to enroll in the study by placing their initials at the end of the document.

Following the assent procedure, participants were administered the executive functions tests on an iPad, which consisted of the List Sorting Working Memory Test, the Flanker task, and the Dimensional Change Card Sort test. In visit two groups of 2-3 participants completed the PedsQL, PAQ-C and the GaBSCI surveys by paper and pencil. Participants were asked to record their answers for each question only after each question was read aloud by the student investigator. Visit three occurred on a separate day, where participants were familiarized with the proper saliva collection protocol and were given the saliva collection materials and directions for the first saliva sample collection. Participants were asked to collect their saliva at home the following morning, 15-20 minutes upon awakening, before brushing their teeth and consuming any food.

Visit four occurred on the same day as their morning saliva collection, but towards the end of the school day. Students were asked to rinse their mouths to remove any food debris and were given 5 minutes to sit in the designated space before undergoing the saliva collection procedure. All visits for the data collection procedures for each school site took place over a two-week time period. Visits 1 (executive functions tests) and visits 2 (PedsQL, PAQ-C, and GaBSCI) occurred during the first 10 days of data collection. Visits 3 (saliva collection familiarization) and 4 (afternoon saliva collection) occurred during the last 4 days of data collection, with the morning and afternoon saliva collection taking place during the last two days of data collection. Depending on when visit 1 was conducted, participants may have had approximately 3-7 days in between their executive functions tests and their saliva collection.

Instruments

NIH Toolbox: Cognition battery. There is a general consensus among scholars on three core executive functions: inhibition, working memory and cognitive flexibility (Diamond, 2013; Lehto et al., 2003; Miyake et al., 2000). To measure executive functions among the participants, response accuracy and reaction time were recorded on an attentional inhibition, working memory and cognitive flexibility task. The cognitive assessments were from the National Institutes of Health (NIH) Toolbox: Cognition Battery. The NIH Toolbox Cognition Battery is a brief, convenient set of measures performed on an iPad, to supplement other outcome measures in epidemiologic and longitudinal research. The psychological tests from the NIH toolbox that were utilized to measure attentional inhibition, working memory and cognitive flexibility include the Flanker task (Eriksen, Eriksen, 1974), the List Sorting Working Memory Test and the Dimensional Change Card Sort Test, which were all performed on the iPad. Test-retest reliability was strong for these three tests, with intraclass correlation coefficients ranging from 0.89-0.96. Correlations for convergent validity range from r = 0.48-0.69 ($p<0.0001$) (Weintraub, 2013; Zelazo, 2013).

NIH Toolbox: Flanker task. Inhibition involves the ability of a person to control one's attention, thoughts, and behaviors to overcome internal impulses and external distractions, to stay on task (Diamond, 2013). The Flanker task is a psychological test that requires and measures inhibition. The Flanker task measures inhibition by engaging participants in a series of trials that have images facing certain directions that either match or do not match. The participants were required to focus their attention on the centrally presented stimulus and ignore the flanking stimuli around it. The objective of this task was to press either the right or left button on the touch screen monitor as quickly and accurately as possible, based on the direction in which the middle stimuli was facing.

NIH Toolbox: List sorting working memory test. Working memory refers to the ability to a) process information across a series of tasks, b) hold the information in a short-term buffer, c) manipulate the information and d) hold the products of that manipulation in the same short-term buffer (Weintraub et al., 2013). A psychological test that measures working memory is the List Sorting Working Memory test. This test involved a series of stimuli presented on the computer screen visually and orally, one at a time. Participants were instructed to repeat the stimuli to the examiner in the order of size, from smallest to largest. In one condition, all stimuli came from one category. In the second condition, stimuli were presented from two categories, following which, the participant attempted to report first, all stimuli from category one in size order, then from the category two, also in size order. The number of items in each series increased from one trial to the next and the test was discontinued when two trials of the same length were failed (Weintraub, 2013). The test scores consist of total items correct across all trials.

NIH Toolbox: Dimensional change card sort. Cognitive flexibility involves the ability to change perspectives spatially or interpersonally. Cognitive flexibility also involves changing how we think about a particular matter, and being flexible enough to adjust to changed demands (Diamond, 2013). The Dimensional Change Card Sort is a task that has been used extensively to study the development of executive functions in childhood (Zelazo et al., 2013). In this test, the stimuli were bivalent, and the correct response for one task is incorrect for the other, but only one switch occurred during the entire test. Participants were given a series of trials in which they were shown pictorial stimuli on a touch screen monitor, and were instructed to match centrally presented test stimuli to one of the two lateralized target stimuli. Participants were instructed to match either by shape or by color by touching the target stimulus that matched the test stimulus on the relevant dimension (Zelazo et al., 2013). Scoring for this test incorporates both accuracy and reaction time.

Salivary cortisol. Exposure to stressors such as living in poverty, activates the physiologic response to stress, where the activation of the sympathetic-adrenal-medullary (SAM) axis and hypothalamic-pituitary-adrenal (HPA) axis secretes catecholamines and glucocorticoids, eventually leading to the release of several stress hormones including cortisol (Flier, Underhill & McEwen, 1998). Cortisol is an important biomarker of stress and grants insight into HPA axis activation and dysregulation.

Cortisol can be assessed through serum, plasma, saliva, urine and hair samples. Both saliva and serum samples provide a measurement of the cortisol concentration at a single point in time and are used to test acute changes in the stress response. Twenty-four-hour urinary samples are another strategy utilized by researchers to examine daily cortisol concentrations and is less influenced by the diurnal variation. However, obtaining urinary samples can be moderately invasive and may pose issues when collecting from children. Due to their invasive nature, serum and urinary samples may also induce the stress response during data collection, providing a false measurement of systemic cortisol. Obtaining multiple salivary samples throughout the day, over several days is a strategy researchers have used to measure levels of stress, yet can be experimentally complex and relies significantly on participant compliance (Russell, Koren, Rieder & Van Uum, 2012). Procedural measures such as checklists, emails and text messaging have been used to ensure compliance of at-home salivary sample collections (Hanrahan, McCarthy, Kleiber, Lutgendorf, & Tsalikian, 2006; Jessop & Turner-Cobb, 2008). This study collected saliva samples in one day, including at-home and in school.

Salivary cortisol was collected at two time points (morning and afternoon), in one day, during the end of the school week (Thursday-Friday). Saliva samples were collected at one time point in the morning upon awakening (Time 1) and at the end of school day (Time 2). An oral swab method was used to collect saliva samples, recommended to help increase participant compliance for participants over 6 years of age. Participants were given a pre-packaged kit that contains a synthetic, hygienic oral swab, a swab storage tube, and sample collection instructions. To collect saliva, participants were instructed to place the oral swab under the tongue for approximately 1-2 minutes to ensure adequate volume. Afterwards, participants immediately placed the oral swab in the swab storage tube and secured the tube tightly. Once the morning samples were collected and brought to school, they were frozen at -20° degrees Celsius (temperature of a regular household freezer).

The morning saliva samples were collected under the direction of a parent/guardian. In addition to the familiarization session given to the participants, detailed instructions for saliva collection were also sent home with the participants, outlining the exact times after awakening and guidelines required to collect appropriate samples. To ensure samples were taken appropriately, a label was also included with each morning sample that required the parent/guardian to record the time that each sample was taken. The afternoon sample occurred under the direction of the student investigator, and took place in a designated room, within the school building during the last 2 hours of the school day. Following the collection of the afternoon samples, all saliva samples were immediately placed in a freezer at -20° Celsius until packaging for shipment.

Samples that were collected in Arizona were shipped on 28 pounds of dry ice, priority overnight express via FedEx overnight delivery, to the Human Performance Laboratory at the University of Connecticut, where they were stored in a freezer at -20° Celsius until analysis. Shipping of all samples took place in accordance with the International Air Transport Association (IATA) dangerous goods regulations. Salivary cortisol samples were then analyzed at the Human Performance Laboratory at the University of Connecticut, using an expanded range high sensitivity salivary cortisol enzyme immunoassay kit (Salimetrics, LLC), according to the manufacturer's instructions.

Assays were performed for all salivary cortisol samples over a period of 1 week. On the day of the assays, samples were thawed for one hour before centrifuging at 1500 rpm for 15 minutes. Samples were then pipetted into the appropriate test wells. In an effort to minimize variability, all samples from each subject were assayed within the same assay batch and were assayed with the same reagents from the same lot. Additionally, as another measure of control, half the samples for each assay batch were assigned to school A and the remaining half for schools B and C. All samples were tested in duplicate.

Pubertal maturation observational scale (PMOS). With the development of the frontal lobe of the brain continuing on through late adolescence and cognitive functioning displaying an improvement associated with maturation, accounting for pubertal maturation is necessary (Davies & Rose, 1999). To measure pubertal maturation, the Pubertal Maturation Observational Scale (PMOS) was utilized. The PMOS classifies individuals into their respective developmental stages by investigator observation and parental report. The PMOS uses two separate checklists of secondary sex characteristics for males and females and classifies each participant as pre-pubertal, mid-pubertal or post-pubertal according to the expression of these characteristics. If a participant has one or no characteristics on the checklist, they were placed in the pre-pubertal stage. Participants with two to five characteristics, including the characteristic of a growth spurt, were classified in the pubertal stage. Participants possessing six characteristics, and past the growth spurt, were categorized in the post-pubertal stage (Davies & Rose, 2000). A growth spurt is defined as an increase in height 3-4 inches in the past year.

The PMOS has been shown to have strong convergent validity ($r = 0.96$ for females and $r = 0.91$ for males) with the Pubertal Development Scale (PDS), which is another measure of pubertal development with established reliability and validity. Furthermore, the reliability of the PMOS to classify participants into developmental stages, has also demonstrated to be high (Hewett, Myer & Ford, 2004; Quatman, Ford, & Myer, 2006). This scale was sent home with the parental permission forms and was completed by parents who opted to have their children participate in the study.

Pediatric quality of life inventory 4.0 (PedsQL 4.0). Many factors and circumstances occur within the microsystem of youths that may affect executive functions, stress regulation and overall health. Because it was outside the scope of this study to identify exposure to specific adverse experiences in childhood and due to experimental and ethical concerns that arise from asking children about adversity, the adverse childhood experiences survey was not used. The PedsQL 4.0 measures perceptions of physical, emotional, and social health and can grant insight into the potential adversity experienced among youth in poverty, without specifically asking about adversity. Additionally, greater exercise and physical activity participation across racial groups and among overweight youth has been shown to be related to greater perceptions of quality of life (Kelly et al., 2011; Lin, Su & Ma, 2012; Shoup, Gattshall, Dandamudi & Estabrooks, 2008). Therefore, to assess whether perceptions of health-related quality of life is associated with executive functions scores, stress levels and physical activity participation, the Pediatric Quality of Life Inventory (PedsQL 4.0) was utilized.

The PedsQL inventory is a self-report format completed by the participant. This instrument is a 23-item questionnaire that measures physical functioning (8 items), emotional functioning (5 items), social functioning (5 items), and school functioning (5 items) among youth ages 2 to 18. The instructions ask how much of a problem each item has been during the past month. A 5-point response scale is used across both forms and range from 0 = never a problem; 1 = almost never a problem; 2 = sometimes a problem; 3 = often a problem; 4 = almost always a problem. Items are reverse scored (0 = 100, 1 = 75, 2 = 50, 3 = 25, 4 = 0), so that higher scores indicate better health related quality of life. Scale scores are then computed as the sum of the items answered, divided by the items answered.

Internal consistency reliability for the total scale score ($\alpha = 0.88$ child, 0.90 parent report), physical health summary score ($\alpha = 0.80$ child, 0.88 parent) and psychosocial health summary score ($\alpha = 0.88$ child, 0.90 parent) were acceptable for group comparisons (Varni, Seid & Kurtin, 2001). Construct validity was determined utilizing the known groups method, which scales scores across groups known to differ in the health construct being investigated. One-Way ANOVAs comparing chronically ill, acutely ill, and healthy children for all scales demonstrated significant differences among the three groups (Varni, Limbers, & Burwinkle, 2007; Varni, Seid, & Kurtin, 2001).

Physical activity questionnaire (PAQ C). Various types and levels of physical activity participation are associated with a number of physical and cognitive health benefits and/or health risks. With moderate-to-vigorous aerobic physical activity showing to improve executive functions (Hillman, et al., 2014), as well as participation in tae kwon do (Lakes & Hoyt, 2004) and yoga (Flook et al., 2015), it was particularly important to use a valid tool that accurately measures physical activity participation among youth. The Physical Activity Questionnaire for Older Children (PAQ-C) provides a general measure of physical activity for youth from grades 4-8. The PAQ-C is a self-administered 7-day recall questionnaire that measures general moderate to vigorous physical activity levels during the school year. Specifically, the PAQ-C measures physical activity from nine items, each scored on a five-point scale. The nine items include: (1) spare time activity, (2) physical education class, (3) recess, (4) lunch, (5) right after school, (6) evening, (7) weekends, (8) describes you best, and (9) the frequency of physical activity for each day the past week. PAQ-C summary scores were derived by taking the mean of the nine-item values, where a score of one indicates low physical activity and a score of five indicates high physical activity.

The reliability (G = 0.90 and G = 0.85), internal consistency (α = 0.79 and α = 0.89), convergent validity (r = 0.63 and r = 0.53) and construct validity (r = 0.57) of the PAQ-C have been established (Crocker, Bailey, Faulkner, Kowalski, & McGarth, 1997; Kowalski, Crocker, & Faulkner, 1997). Additionally, a more recent study by Stockton, McGuire, Nettlefold, Tomlin, McKay, and Naylor (2009) explored the validity and reliability of the PAQ-C using accelerometry and found significant relationships between the PAQ-C scores and accelerometry variables of physical activity a day (r = 0.48, $p < 0.001$), counts per day (r = 0.43, $p < 0.00$), and counts per minute (r = 0.46, $p < 0.00$), with internal consistency of the PAQ-C being in the acceptable range (Cronbach's α = 0.76). Overall, the PAQ-C is a reliable and valid measurement to account for physical activity among youth and was utilized in this study.

Georgia brief school climate inventory (GaBSCI). The National School Climate Center (2017) defines school climate as the "quality and character of school life," which includes the quality of relationships among students with their peers and their teachers. School climate also includes the totality of school experiences and can affect students within the school either positively or negatively. Positive school climate has been shown to foster positive behavioral, psychological and academic outcomes in students (Wang & Degol, 2015). Meanwhile, a negative school climate has been associated with a variety of risky behaviors among students including underage drinking, frequency of illicit drug use (Ryabov, 2015), increased bullying (Wang, Berry & Swearer, 2013), absenteeism, anxiety, oppositional behavior (Hendron & Kearney, 2016) dropping out (Kotok, Ikomo, & Bodovski, 2016) and lower academic achievement (Wang & Degol, 2015). School climate measures are necessary given the vast amount of experiences and interactions that students undergo while attending school and the potential for those to affect stress regulation.

The Georgia brief school climate inventory (GaBSCI) was used in this experiment and was a measure of student perceptions of school climate. The GaBSCI is a 9-item instrument that addresses student perceptions of three dimensions of school climate: Safety, learning, and relationships. In the first seven items of the inventory, participants were asked to choose from the following response options: *always* (scored as 2 points), *sometimes* (scored as 1 point), *and never* (scored as 0 points). Responses to a school safety question were *always* (scored as 3 points), *sometimes* (scored as 2 points), *not really safe* (scored as 1 point), *and no, it's dangerous* (scored as 0 points). Lastly, responses to school relationships item were *yes* (scored as 1 point) *and no* (scored as 0 points). The final score of the GaBSCI was the sum of the scores and ranged from 0 to 18, with a score of 0 representing perceptions of a poor school climate and a score of 18 representing perceptions of an ideal school climate. The Cronbach alpha for the scale was 0.71, with exploratory and confirmatory factor analyses verifying the scale's structure (RMSEA of 0.51, 95% CI [0.049, 0.052], SRMR of 0.041). Furthermore, construct validity was obtained based on its relationships with behaviors related to bullying (White, La Salle, Ashby & Meyers, 2014).

Data Analysis

Pearson moment correlations were used to test hypotheses 1-4 and to elucidate relationships between executive functions scores, pediatric quality of life scores, physical activity participation scores, salivary cortisol, age, grade and pubertal status. To carry out the planned analyses and to assess mean differences between active and inactive participants, all participants were coded into one of two groups according to their scores on the PAQ-C. Benetiz-

Porres, Alvero-Cruz, Sardinha, Lopez-Fernandez, and Carnero (2016) revealed that a score of 2.75 on the PAQ-C is a valid cut-off point that distinguishes children who have achieved the recommended 60 minutes of moderate to vigorous activity, 5 days a week. Whereas participants who scored below 2.75 on the PAQ-C failed to meet the recommended 60 minutes of moderate to vigorous activity, 5 days a week (Benetiz-Porres et al., 2016). Subsequently, participants who scored 2.75 or higher on the PAQ-C were categorized into the active group, and participants who scored lower than 2.75 were categorized into the inactive group.

Furthermore, with school A providing its students with the opportunity to participate in 90 minutes of in-school physical activity (45 minutes of physical education and 45 minutes of recess) 4 days a week, and 120 minutes of after-school sport 5 days a week, it was expected that school A would have greater reported PAQ-C scores than schools B and C. An initial three-way multivariate analysis of covariance (MANCOVA) confirmed this assumption with school A having a statistically significant difference in the PAQ-C summary scores (0.671, 95% CI [0.378, 0.965], $p < 0.00$; marginal means 3.342, SE 0.092), compared to schools B and C (marginal means 2.671, SE 0.116). However, the interaction effect between schools, sex and grade on the combined PAQ-C variables was not statistically significant (F (30,378) = 0.975, $p = 0.489$, Wilks' λ, = 0.797, partial $\eta^2 = 0.073$). Therefore, in order to isolate the effects of physical activity participation, independent of racial, ethnic, cultural differences, region, climate and opportunities for sport and physical activities, the 2.75 PAQ-C threshold was utilized to separate study participants into dichotomous groups. A statistically significant difference was found between active participants and inactive participants on the PAQ-C variable (F (3,128) = 58.49, $p < 0.000$, Wilks' λ, = 0.422, partial $\eta^2 = 0.578$; 1.21, 95% CI [2.064, 2.370], $p < 0.00$; active marginal means 3.43, SE 0.054, inactive marginal means 2.217, SE 0.077).

Nevertheless, there remains a challenge with grouping participants according to activity status, since school A was significantly different in the PAQ-C scores (0.671, 95% CI [0.378, 0.965], $p < 0.00$; marginal means 3.342, SE 0.092) than schools B and C. Additionally, school A had more participants in the active group (n = 54 active), than schools B and C (n = 35 active), while schools B and C had more participants in the inactive group (n = 43 inactive) than school A (n = 17 inactive). Yet, categorizing participants based on their reported PAQ-C scores does combine groups based on variables other than physical activity. In an ideal analysis, categorizing participants according to activity status would result in no statistically significant differences between school A and schools B and C on the PAQ-C, but statistically significant differences in PAQ-C scores according to activity status. Despite the challenges mentioned, utilizing this method of categorizing two groups according to activity status represented the best option to examine differences in executive functions scores and salivary cortisol levels and to improve generalizability among youth in poverty.

Therefore, to test hypotheses 5 a two-way multivariate analysis of covariance (MANCOVA) was utilized to further assess mean differences between activity status for scores on the flanker task, list sorting working memory test and the dimensional change card sort task. Furthermore, to test hypothesis 6, an additional two-way multivariate analysis of covariance (MANCOVA) was conducted to assess mean differences between activity status for morning salivary cortisol, end of the school day salivary cortisol and the difference of morning to afternoon salivary cortisol levels.

Results

Participants

Seventy-one participants from school A were enrolled in the study. One hundred and fifty-three students from school A were qualified to participate in the study, with 46% of students participating. One hundred and twenty-six students in school B were qualified to participate in the study, and 39 participants from school B were enrolled (31%). One hundred and fifty-six students in school C were qualified to participate in the study, with 39 participants enrolling (25%). A total of 149 students across all three schools were enrolled in the study (*N* = 149). Fifty-four percent of the study participants were male, while 46% were female. Furthermore, 17% of the participants were in the 5th grade, 42% in the 6th grade, 21% in the 7th grade and 20% of the participants were in the 8th grade. A total of 89 participants scored 2.75 or above on the PAQ-C and were categorized as the active group, while 60 participants scored below 2.75 on the PAQ-C and were categorized into the inactive group. 57% of the active participants were males (*n* = 51) and 43% of active participants were females (*n* = 38). Additionally, 48% of participants in the inactive group were males (*n* = 29) and 52% of participants in the inactive group were females (*n* = 31). Seventeen participants from school A were categorized as inactive, and 54 were categorized as active. Seventeen participants from school B were categorized as active and 22 students were categorized as inactive. Lastly, 17 participants from school C were also categorized as active, and 22 students were also categorized as inactive.

Table 2

Participant Characteristics

	Active	Inactive
N	89	60
Males (n)	51 (57%)	29 (48%)
Females (n)	38 (43%)	31 (52%)

5th Grade (n)	19 (21%)	7 (12%)
6th Grade (n)	29 (33%)	33 (55%)
7th Grade (n)	23 (26%)	9 (15%)
8th Grade (n)	18 (20%)	11 (18%)

Table 3

Means and Standard Deviations of PAQ-C, PedsQL and GaBSCI

	PAQ-C	PedsQL	GaBSCI
Active	3.49 (± 0.54) *	80.85 (± 11.96)	13.02 (± 2.50)
Inactive	2.10 (± 0.46)	78.38 (± 13.16)	12.62 (± 3.32)

Note. * = Statistically significant at the $p < 0.05$ level

Table 4

Means and Standard Deviations of Executive Functions Tests

	Dimensional Change Card Sort Test	Flanker Test	List-Sorting Working Memory Test
Active	51.14 (± 10.78)	44.66 (± 8.22)	46.11 (± 9.69)*
Inactive	49.70 (± 12.14)	46.39 (± 10.98)	42.66 (± 6.95)

Note. * = Statistically significant at the $p < 0.05$ level

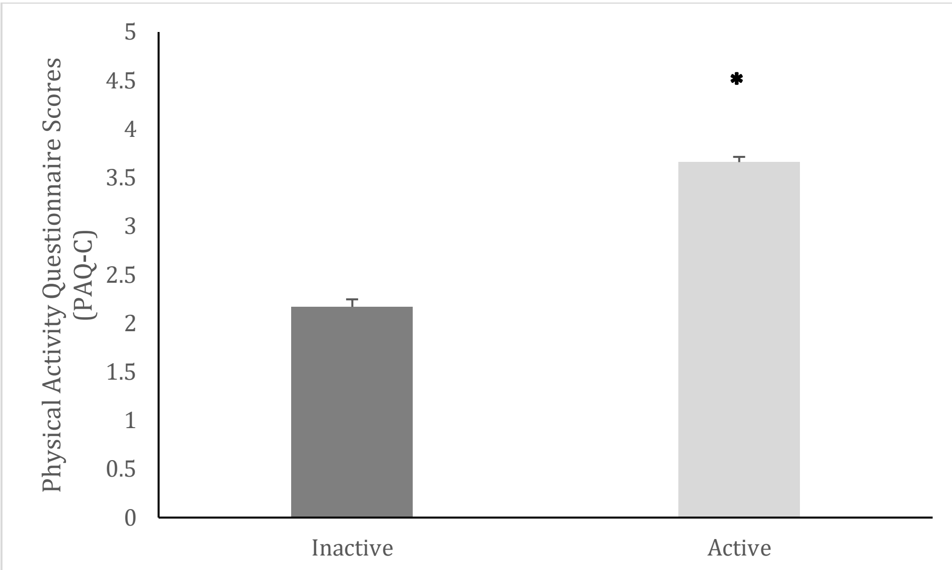
Table 5

Means and Standard Deviations of Salivary Cortisol

	A.M Salivary Cortisol	P.M Salivary Cortisol
Active	0.44 (± 0.49)	0.33 (± 0.49)
Inactive	0.33 (± 0.15)	0.32 (± 0.55)

Chart 1

Physical Activity Questionnaire (PAQ-C) Between Activity Status



Note. * = Statistically significant at the $p < 0.05$ level

The Relationship Between Health-Related Quality of Life and Salivary Cortisol

A Pearson's product-moment correlation was run to assess the relationship between PedsQL scores, A.M salivary cortisol, P.M salivary cortisol and the mean change between A.M and P.M salivary cortisol. Preliminary analysis revealed all variables were normally distributed as assessed by Shapiro-Wilk's test ($p < 0.05$). There were no statistically significant correlations between the PedsQL scores and AM salivary cortisol (-0.059, $p = 0.472$), PM salivary cortisol (-0.116, $p = 0.159$) and the differences between A.M and P.M salivary cortisol (0.091, $p = 0.269$). Subsequently, I failed to reject null hypothesis 1, which states that there is no statistically significant relationships between health-related quality of life scores and salivary cortisol levels.

The Relationship Between Health-Related Quality of Life and Physical Activity

A Pearson's product-moment correlation was run to assess the relationship between PedsQL scores and the PAQ-C scores. Preliminary analysis revealed the PAQ-C scores were not normally distributed as assessed by Shapiro-Wilk's test ($p = 0.400$), but the PedsQL scores were normally distributed. A statistically significant positive correlation was found between the health-related quality of life scores and the physical activity scores ($r = 0.211$, $p = 0.01$). Therefore, I rejected null hypothesis 2 which states that there is no statistically significant correlations between the PedsQL scores and the PAQ-C scores.

The Relationship Between Health-Related Quality of Life and Executive Functions

A Pearson's product-moment correlation was run to assess the relationship between the PedsQL scores and the scores on the cognitive flexibility, inhibition and working memory tests. Preliminary analysis revealed the cognitive flexibility scores were not normally distributed as assessed by Shapiro-Wilk's test ($p = 0.528$), but the inhibition, working memory and PedsQL scores were normally distributed ($p < 0.05$). There were no statistically significant correlations between the PedsQL scores and cognitive flexibility (r = 0.023, $p = 0.776$), inhibition ($r = 0.030$, $p = 0.720$) and working memory ($r = -0.25$, $p = 0.760$) test scores. Consequently, I failed to reject null hypothesis 3 which states that there are no significant relationships between PedsQL scores and cognitive flexibility, inhibition and working memory test scores.

The Relationship Between Salivary Cortisol and Executive Functions

A Pearson's product-moment correlation was run to assess the relationship between A.M salivary cortisol, P.M salivary cortisol and the scores on cognitive flexibility, inhibition and working memory tests. Preliminary analysis revealed the cognitive flexibility scores were not normally distributed as assessed by Shapiro-Wilk's test ($p = 0.528$), but the inhibition, working memory and salivary cortisol measures were normally distributed ($p < 0.05$). There was a statistically significant positive correlation between P.M salivary cortisol and inhibition scores ($r = 0.211$, $p = 0.01$). Yet there were no statistically significant relationships found between A.M salivary cortisol and cognitive flexibility (*r* = 0.027, *p* = 0.743), inhibition (*r* = 0.051, *p* = 0.537) and working memory (*r* = 0.069, *p* = 0.401) test scores. Furthermore, there were no statistically significant relationships between P.M salivary cortisol and cognitive flexibility (*r* = 0.104, *p* = 0.206) and working memory (*r* = 0.160, *p* = 0.051). Therefore, I rejected null hypothesis 4, which states that there is no correlation between salivary cortisol levels and executive functions scores, since there was a statistically significant positive relationship between PM salivary cortisol and inhibition scores.

Table 6

Pearson correlations

	PAQ-C	PedsQL	GaBSCI	DCCS	Flanker	List-sorting	A.M Cortisol	P.M Cortisol
PAQ-C	1	0.21**	0.08	0.18*	0.02	0.15	0.12	0.04
PedsQL	0.21**	1	0.20*	0.02	0.03	-0.02	-0.06	-0.12
GaBSCI	0.08	0.20*	1	0.04	0.01	-0.05	0.04	0.00
DCCS	0.18*	0.02	0.04	1	0.60**	0.24**	0.03	0.10
Flanker	0.02	0.03	0.01	0.60**	1	0.19*	0.05	0.21**
List-Sorting	0.15	-0.02	-0.05	0.24**	0.19*	1	0.07	0.16
A.M Cortisol	0.12	-0.06	0.04	0.03	0.05	0.07	1	0.65**
P.M Cortisol	0.04	-0.12	0.00	0.10	0.21**	0.16	0.65**	1

Note. ** = statistically significant at the $p < 0.01$ level. * = statistically significant at the $p < 0.05$ level.

Differences in Executive Functions Between Activity Status

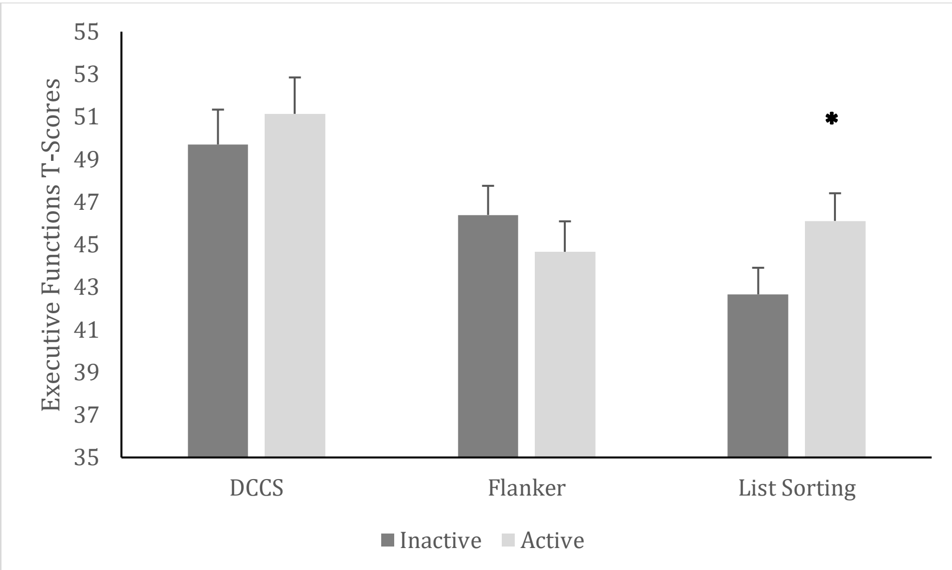
In order to examine differences between active and inactive participants, a two-way multivariate analysis of covariance was used to determine the effect of two independent variables of activity status and pubertal status, while controlling for age, sex and grade level (Gur et al., 2012; Lemaire & Lecacheur, 2011; Matsuzawa et al., 2001; Perrin et al., 2009) on the dependent variables of the dimensional change card sort test scores, flanker score, and the list sorting working memory test score. The interaction effect between activity status and pubertal status on the combined executive functions variables was not statistically significant ($F(6,276) = 0.629$, $p = 0.707$, Wilks' λ, = 0.973, partial $\eta^2 = 0.013$). Meanwhile, there was a statistically significant main effect of activity status on the combined executive functions variables ($F(3,138) = 2.793$, $p < 0.043$, Wilks' λ, = 0.943, partial $\eta^2 = 0.057$), after controlling for age, sex and grade level.

Follow up univariate two-way ANOVAs were run and the main effect of activity status were considered. There was a statistically significant main effect of activity status for the list sorting working memory test scores ($F(1,140) = 5.303$, $p = 0.023$, partial $\eta^2 = 0.036$), yet there were no statistically significant main effects of activity status for the dimensional change card sort test score ($F(1,139) = 0.108$, $p = 0.743$, partial $\eta^2 = 0.001$) or the flanker test scores ($F(1,139) = 1.008$, $p = 0.317$, partial $\eta^2 = 0.007$).

Pairwise comparisons were run with the Bonferroni adjustment to assess differences in mean for the list sorting working memory test scores between activity status. The list sorting working memory test scores were 3.497, 95% CI [0.495, 6.499] significantly higher in active participants, compared to inactive participants ($p = 0.023$). The marginal means for the list sorting working memory test score were 46.439 (SE 0.934) for active participants and 42.942 (SE 1.200) for inactive participants, a statistically significant difference of 3.497, 95% CI [0.495, 6.499] ($p = 0.023$). Therefore, null hypothesis 5 was rejected, which states that there is no statistically significant difference in cognitive flexibility, inhibition and working memory scores between more active youth and less active youth. More active youth displayed greater scores on one of the three executive functions tests (list sorting working memory test) than less active participants.

Chart 2

Differences in Executive Function Scores



Note. * = Statistically significant at the $p < 0.05$ level

Differences in Salivary Cortisol Between Activity Status

A separate two-way multivariate analysis of covariance (MANCOVA) was used to determine the effect of the two independent variables of activity status and grade level, while controlling for age, sex and puberty level (Barra, Silva, Rodrigues, Santos & Colosimo, 2015; Kiess, Meidert, Dressendorfer, Scheiver, Kessler & Konig, 1995; Lupien, King, Meaney & McEwen, 2001) on the dependent variables of morning salivary cortisol levels, afternoon salivary cortisol levels and the difference between the morning and afternoon salivary cortisol levels. The interaction effect between activity status and grade level on the combined stress variables was not statistically significant (F (9,414) = 1.884, p = 0.053, Pillai's Trace, = 0.118, partial η^2 = 0.039). However, there was a statistically significant main effect of activity status on the combined stress variables (F (3,136) =3.991, p = 0.009, Pillai's Trace, = 0.081, partial η^2 = 0.081), after controlling for age, sex and puberty status.

Follow up univariate two-way ANOVAs were performed and the main effect of activity status were considered. There was a statistically significant main effect of activity status for the differences between morning and afternoon salivary cortisol levels (F (1,138) = 11.387, p = 0.001, partial η^2 = 0.076), yet there were no statistically significant main effects of activity status for morning salivary cortisol levels (F (1,138) = 1.841, p = 0.177, partial η^2 = 0.013) or afternoon salivary cortisol levels (F (1,138) = 1.752, p = 0.188, partial η^2 = 0.013).

Pairwise comparisons were run with the Bonferroni adjustment to assess differences in mean for the differences of morning and afternoon salivary cortisol levels between activity status groups. The differences of salivary cortisol levels were .217, 95% CI [0.090, 0.345] greater in active participants, compared to inactive participants, a statistically significant difference of p = 0.001. The marginal means for the differences of salivary cortisol levels were 0.094 (SE 0.037) for active participants and -0.123 (SE 0.053) for inactive participants, a statistically significant difference of 0.217, 95% CI [0.090, 0.345] (p = 0.001). Subsequently, I failed to reject null hypothesis 6, which states that there are no statistically significant differences in salivary cortisol levels between active and less active youth. More active youth displayed no statistically significant differences between morning and afternoon salivary cortisol levels than less active participants.

Chart 3

Differences in Morning and Afternoon Salivary Cortisol

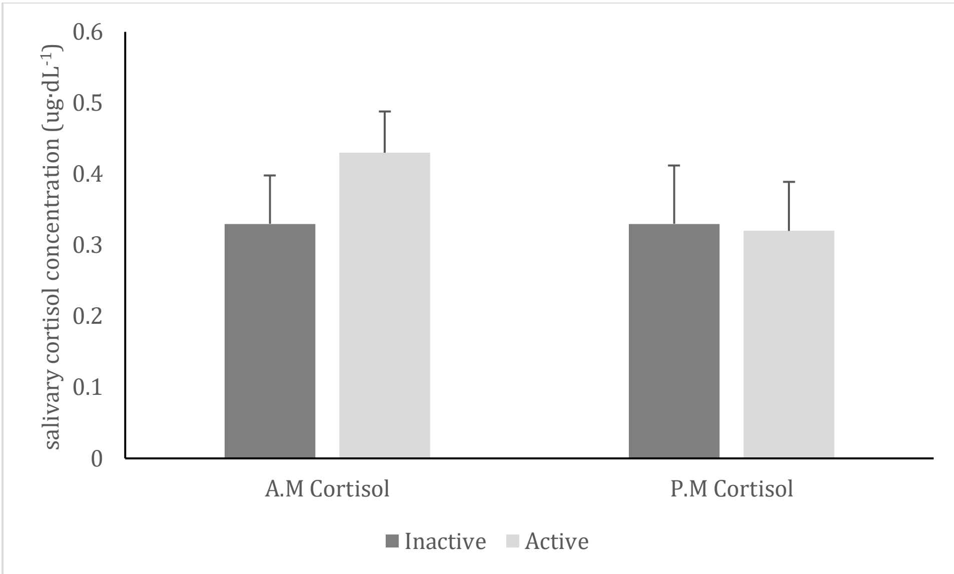
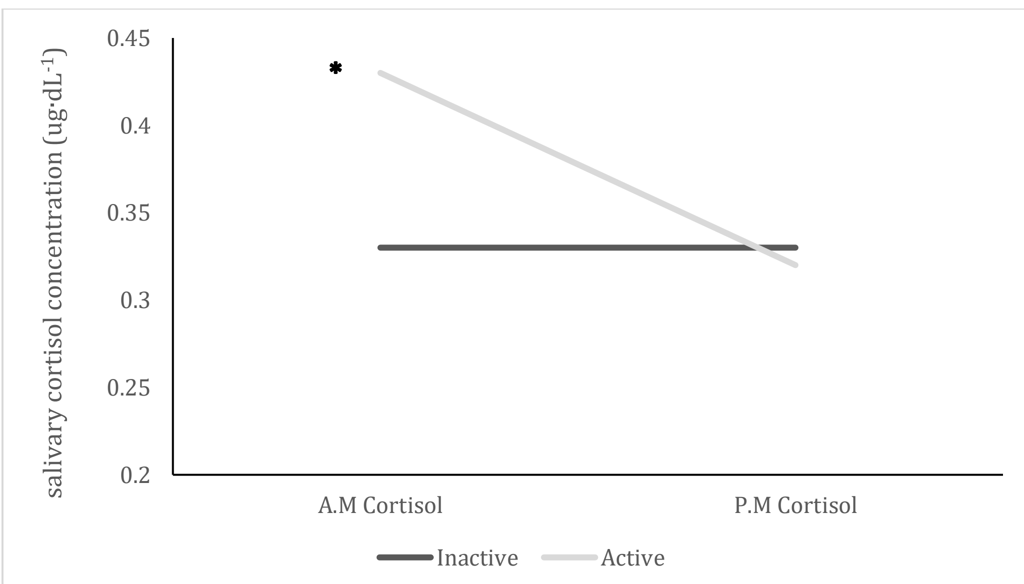


Chart 4

Differences in Change from Morning to Afternoon Salivary Cortisol



Note. * = Statistically significant at the p < 0.05 level

Discussion

Health-Related Quality of Life and Salivary Cortisol

The lack of a statistical significant relationship of the PedsQL scores to the different time points of salivary cortisol levels was an unexpected result. Given that living in urban poverty is associated with greater exposure to adverse experiences (Burke et al., 2011), there was an expectation to see significant relationships between PedsQL scores and salivary cortisol levels. The lack of significant relationships among these variables may suggest the interaction of different factors within the microsystem of youth that may buffer exposure to adversity. Factors such as the presence of a caring adult at home and/or at school and positive peer relationships in and outside of school, may help explain the lack of a relationship between PedsQL scores and salivary cortisol levels. The interaction of different actors within the microsystem of youth is also supported by the focus group data. Across school types, students reported both positive and negative experiences among peers, and both positive and negative experiences with adults in the schools. These antagonistic experiences reveal daily interactions among different actors within schools that may be exacerbating or attenuating HPA axis activity among youth.

While there has yet to be research examining relationships between these specific constructs, studies have shown how health related quality of life scores were significantly lower among urban youth in poverty (mean= 67.2 ± 16.2) compared to children who were deemed as "healthy" (mean= 83) (Mansour et al., 2003; Varni, Seid, & Kurtin, 2001). In this study the mean score for the PedsQL was 79.6 ± 12.5 for all participants, which is significantly higher than the original scores of urban youth reported by Mansour et al. (2003), yet still below the "healthy" children in the Varni et al. (2001) study. The higher average perceptions of health-related quality of life among the study sample may be one of the factors that contributed to the lack of a statistically significant result with salivary cortisol levels. Despite the majority of the participants living at or below the poverty threshold, participants still reported above average PedsQL scores for urban youth in poverty.

The PedsQL scores may also allude to the variety of experiences that youth in urban poverty may undergo, and contradicts the assumption that all youth in poverty share a monolithic experience. While limited research exists examining the positive aspects of living in poverty, an early qualitative study on African-American families in poverty conducted by Jarret (1995), revealed different family strategies that were employed to support youth to become socially mobile, in spite of living in poverty. Strategies such as a supportive adult network structure, stringent parental monitoring strategies, strategic alliances with mobility-enhancing institutions, and adult-sponsored development, were key family characteristics that supported youth. This reveals the diversity of family experiences that youth living in poverty may encounter and may help explain the lack of a relationship between PedsQL score and salivary cortisol.

Health-Related Quality of Life and Physical Activity Participation

The significant relationship found between overall physical activity (PAQ-C) scores and the health-related quality of life inventory (PedsQL) (r = 0.211, p < 0.01) supports previous research that has assessed physical activity and well-being of children from social disadvantaged areas (Breslin et al., 2017; Crews, Lochbaum, & Landers, 2004; Kelly et al., 2010). Yet, the results from the MANCOVA revealed no statistically significant differences between active and inactive participants on the PedsQL scores. This also aligns with Boyle, Jones, and Walters (2010) who found no statistically significant differences on the PedsQL between children who achieved the recommended physical activity guidelines and those who did not. The discrepancy between these two findings may point toward the complexity of how youth perceive their health and quality of life. The physical functioning domain on the PedsQL inventory is only one of the four domains on this scale, with the other domains addressing emotional, social, and school functioning. Greater physical activity participation may not necessarily address the emotional, social, and school aspects of this scale. The quality of physical activity programming is a factor that must be taken into account in order to derive positive emotional and social outcomes in youth.

Regarding the quality of programming, it cannot be assumed that by participating in physical activity and sports, youth only experience positive emotional, social and school outcomes. Physical activity and sport participation itself is complex and depends on the interaction of a variety of factors, including the actors involved (both adults and children), the organizational components and the environment in which the sport or activity takes place. Multiple studies have elucidated negative experiences of sport and physical education participation, where children have reported feelings of rejection, exclusion, harassment, and emotional harm from both their peers and coaches (Beltran-Carillo, Devis-Devis, Peiro-Velert, & Brown, 2012; Bradley, Zi, & Marita, 2013; Stafford, Alexander, & Fry, 2015). Therefore, perceptions of emotional, social and school wellbeing can vary greatly, depending on the quality of physical activities that youth are participating in and the quality of their interactions within these contexts. Greater physical activity participation can impact perceptions of physical, emotional, social, and school well-being, both negatively and positively depending on the experiences and interactions of each child with their peers and coaches. A deeper analysis distinguishing the types and quality of physical activities and sport is needed, in order to discover if participation is related to youth perceptions of health and quality of life.

Salivary Cortisol and Executive Functions

The significant relationship between the Flanker task and the afternoon saliva sample was also an unexpected result, with overexposure to cortisol thought to generally impair executive functions (Danese & McEwen, 2012; Hillman, Khan, & Kao, 2015, Lupien, Maheu, Tu, Fiocco,

& Schramek, 2007; McEwen, 2012). However, the significant relationship of PM salivary cortisol to performance on the Flanker task and the lack of a relationship of AM salivary cortisol to the Flanker task further supports the inverted U theory developed by de Kloet et al. (1999). De Kloet et al. (1999) hypothesized an optimal range of cortisol that enhances cognitive function, with too little or too much cortisol impairing cognitive function. This result also aligns with the work of Lupien et al. (2002) that demonstrated when hydrocortisone was intravenously injected into participants prior to a cognitive task, their performance increased, compared to the placebo group. Also, comparing mean salivary cortisol between participants in the Lupien et al. (2002) study with mean salivary cortisol among participants in this study, reveal similar afternoon cortisol concentrations (mean = 0.40 μg/dL and 0.33 μg/dL respectively). This reinforces the inverted U theory with AM salivary cortisol levels possibly being the threshold to reduced inhibition and PM salivary cortisol being in the optimal range for enhanced inhibition. These findings may grant further understanding into the optimal range of cortisol needed to enhance cognitive function, specifically inhibition.

Additionally, executive functions are generally constructed as three distinct cognitive processes; working memory, cognitive flexibility, and inhibition (Diamond, 2013). Stress has been shown to impair working memory (Schoofs et al., 2008; Shansky & Lipps) and cognitive flexibility (Laredo et al., 2015; Plessow et al., 2011), yet there have been conflicting findings regarding stress enhancing inhibition (Schwabe et al., 2013) or impairing inhibition (Sanger et al., 2014). Therefore, the significant relationship of the Flanker task (which measures inhibition) to afternoon salivary cortisol levels aligns with the work of Schwabe et al. (2013) and Shields et al. (2015), which support the perspective that stress enhances inhibition.

These findings also fit the prevalent theory of how stress improves inhibition, yet hinders cognitive flexibility and working memory. It is thought that in a stress-inducing situation, cognitive resources are prioritized to deal with the current stressor at hand. These cognitive resources would typically be devoted to cognitive flexibility and working memory, yet in the state of heightened stress, these resources are allocated to inhibition to enhance the ability to focus on the current stressor (Shields, Sazma, & Yonelinas, 2016). Therefore, the findings regarding the statistically significant relationship between PM salivary cortisol and inhibition supports this theory of how an optimal level of stress may be related to greater inhibition.

Executive Functions and Activity Status

The results concerning significantly greater scores on the list-sorting working memory test among more active participants supports previous research on the benefits of physical activity on executive functions among youth (Lakes & Hoyt, 2004; Davis et al., 2011; de Greef et al., 2018; Hillman et al., 2014; Schmidt, Jager, Egger, Roebers, & Conzelmann, 2015). While Hillman et al., (2014) reported statistically significant findings for a 9-month physical activity intervention on inhibition among children, the findings in the current experiment did not yield statistically significant results for inhibition. However, the findings on inhibition in this experiment do support a recent meta-analysis by de Greef et al., (2018), which examined 6 studies and found no significant effects of physical activity on inhibition. Additionally, the statistically significant findings for greater working memory among more active participants also aligns with previous research (Kamijo et al., 2011; Schmidt et al, 2015; Van der Niet, Smith, Oosteriaan, Scherder, Hartman, & Visscher, 2016) that report the benefits of physical activity on working memory among children.

Improved executive functions among more physically active youth in poverty is further supported by the lack of a statistically significant mean difference between the PedsQL and GaBSCI surveys between active and inactive participants (p = 0.429). This indicates that both groups had similar perceptions of their quality of life and of their school climate, which may be indicative of the amount of potential adversity experienced by each group. Despite living in poverty, having similar perceptions of their quality of life and school climate, youth who were engaged in higher levels of physical activity had greater working memory scores compared to their less active peers.

These findings in the current study add more insight to the existing physical activity and executive functions literature due to the location and the racial and economic composition of the sample. This study took place in the northeast and southwest of United States with 100% of participants in this experiment being non-white (Black and Latino/a), and the majority (> 92%) of participants being from families that were living at or under the federal poverty level. The majority of prior research examining physical activity participation and exercise on executive functions among children was performed outside the United States (Crova, et al., 2013; Koutsandreou, Wegner, Niemann, & Budde, 2015; Schmidt et al., 2015; van der Niet et al., 2016), with no racial and socio-economic status reported, limiting applicability to different contexts. One study by Hillman et al. (2014) examined children within the mid-western United States, and reported 43% of participants being categorized as low SES, and more than half of the participants being White. An earlier study by Tomporowski et al. (2011) examined exercise and executive functions among overweight children in the southeastern part of the United States, and reported 61% of participants identifying as black, but did not report SES. This study builds upon the current literature by granting further insight into the phenomenon of physical activity and executive functions among historically marginalized groups in the United States.

Examining the role of physical activity on executive functions through the perspective of race and socio-economic status in the United States is important due to the historical and current systemic oppression that these racial and economic groups experience, which are major contributors to executive functions, stress, and life outcomes (Blair et al., 2011; Hair, Hanson, Wolfe, & Pollak, 2015; Pechtel & Pizzagalli, 2011). Additionally, a disproportionate amount of Black (22%) and Hispanic (19.4%) households are living below the poverty line, compared to non-Hispanic Whites (8.8%) (Semega, Fontenot, & Kollar, 2017). Subsequently, a disparate number of Black and Hispanic households are experiencing poverty, which is associated with a number of negative health-related issues including attenuated brain development and executive functions (Hair et al., 2015; Nobel et al., 2015). In addition to disparities in health, research also continues to reveal how living in poverty is related to lower than average academic achievement beginning in kindergarten, continuing through high school and developing into lower than average rates of high school completion (Mulligan, Hastedt, & McCarroll, 2012; Ross et al., 2012). The literacy skills of children from low SES families have also shown to be, on average, 5 years behind those of high-income students, upon entering high school (Reardon, Valentino, Kalogrides, Shores, & Greenberg, 2013). The high school drop-out rate was also the highest among low-income families (11.6%), with individuals from the lowest family income quartile being eight times less likely to obtain a bachelor's degree by age 24, compared to high-income families (Doerschuk et al., 2016; National Center for Education Statistics, 2014).

Assessing the role of physical activity on executive functions among these historically marginalized groups is imperative due to the positive relationships that executive functions have with math and language skills, academic achievement and life outcomes (Cameron et al., 2010; De Franchis, Usai, Viterbori, & Traverso, 2017; Diamond & Ling, 2016). While a paucity exists in physical activity and executive functions research among these historically marginalized groups, the current study addresses this need and provides novel and promising findings for these historically marginalized groups. The novel findings in this study suggest that greater physical activity participation is associated with greater executive functions among youth living in poverty, despite experiencing the stress of living in poverty. These findings are significant since improving executive functions among youth in poverty may not only lead to enhanced cognitive function, but also may lead to improved school readiness, greater math and reading skills and school success (Alloway, Gathercole, Adams, Willis, Eaglen, & Lamont, 2005; Diamond & Ling, 2016). Using physical activity to improve executive functions among youth in poverty may be another strategy to address the gaps in academic achievement among low-income and high-income students and to combat the negative effects of poverty on executive functions among youth living in poverty.

Improving executive functions and academic achievement among groups in poverty also has positive social and economic implications, with greater educational attainment being related to higher rates of employment and higher median incomes among young adults (National Center for Education Statistics, 2017). Therefore, improving executive functions among youth in poverty may also be a way to eventually promote social mobility and improve life outcomes. Another encouraging factor of physical activity being associated with greater executive functions among youth in poverty is its potential to be cost effective to school budgets. Having schools provide greater opportunities to possibly improve executive functions can be implemented by designing physical activity into a lesson plan, or structurally allotted as part of a school day, without incurring significant costs to a school.

Stress Regulation and Activity Status

Even though there were no statistically significant mean differences in morning and afternoon salivary cortisol between active and inactive participants, there were statistically significant mean differences for the changes from morning to afternoon salivary cortisol. More active participants, displayed greater mean differences between morning and afternoon salivary cortisol levels. This elucidates how physical activity may mediate the HPA axis response in youth. These findings are aligned with previous research which has shown how physical activity and fitness level are associated with reduced cortisol concentrations when exposed to psychosocial stress (Martikainen et al., 2013; Rimmele et al., 2007; Strahler, Fuchs, Nater, & Klaperski, 2016; Wood, Clow, Hucklebridge, Law, & Smyth, 2018). However, much of the prior research along this line has examined this phenomenon primarily among adults and athletes. Only the study by Martikainen et al. (2013) assessed physical activity with HPA axis reactivity to stress in children, albeit among 8-year-old children in Finland.

Therefore, the findings in the current experiment provide novel insight regarding the role of greater physical activity in stress regulation among Black and Hispanic, 5th-8th grade youth living in urban poverty. The lack of a statistical mean difference between PedsQL and GaBSCI scores, also reinforces the role that physical activity plays in stress regulation. Despite having similar perceptions to their health with the PedsQL scores (mean = 78.38 and 78.86) and school climate measures (mean = 12.62 and 12.86), more active participants had significantly greater declines in mean salivary cortisol levels (0.10 μg/dL, p = 0.001) from their morning to afternoon time points, than less active participants (0.00 μg/dL, p = 0.001). Increasing physical activity participation among youth in poverty may be a viable strategy to improve stress regulation, which would have profound effects on overall health and cognitive outcomes.

Additionally, examining the levels of salivary cortisol of all the participants in this study according to the normed reference ranges based on Salimetrics standards (2018), reveals normal AM ranges (mean = 0.39 μg/dL), yet higher PM ranges (mean = 0.33 μg/dL), resulting in a flatter salivary cortisol profile. Yet, when compared to similar racial and economic groups, but from a different region in the United States, the cortisol levels were considerably higher for the AM (mean = 0.39 μg/dL), and PM (mean = 0.33 μg/dL) time points for the participants in this study, compared to what was reported in a previous study by Bevans, Cerbone and Overstreet (2008) (AM mean = 0.23 μg/dL and PM mean = 0.11 μg/dL). The study by Bevans et al., (2008) also grants further insight into the different factors that may be contributing to higher PM cortisol levels exhibited by the participants in this study.

Bevans et al. (2008) examined the cumulative effects of recent life stress, previous trauma, and recent trauma exposure on salivary cortisol levels among school-aged children in a K-8 school. The authors reported that exposure to life stress within the past 12 months were related to higher afternoon salivary cortisol levels. Additionally, higher afternoon cortisol levels were related to greater exposure to recent trauma in combination with exposure to trauma earlier in life. Their findings help explain the possibility of past and recurrent trauma exposure contributing to higher levels of afternoon salivary cortisol among the participants in this study. Even though trauma was not specifically measured in this study, due to ethical and experimental concerns of directly asking children regarding potential trauma, traumatic experiences have been found to be more prevalent among groups in poverty (Evans, 2004; Steele et al., 2016). With greater than 92% of the participants in this study living at or under the federal poverty line, a possibility exists that the youth in this study have been exposed to traumatic events during their lifetimes, thereby helping to explain their higher levels of afternoon salivary cortisol

Implications

Results from this study provide insight into the potential of physical activity participation and its potential ability to counteract the negative effects of poverty on executive functions among youth in the 5th-8th grade. With core executive functions being related to and predictive of academic skills, school readiness and achievement (Cameron et al., 2010; De Franchis, Usai, Viterbori, & Traverso, 2017; Vandenbroucke, Verschueren, & Baeyens, 2017), the results in this study can inform the development of novel physical activity interventions as a way to possibly improve youth executive functions and school outcomes. Specifically, school administrators and teachers who operate in districts of poverty can use the findings in this study to provide greater opportunities for their students to engage in quality physical activity, without incurring exorbitant costs. Whether it would mean to structurally change the school day and classes or incorporating more physical activity into the current curriculum, including more physical activity for students is a worthwhile endeavor that may have large implications for health, education, and life outcomes. Providing quality physical activity opportunities would be a valuable way to improve school outcomes and may buffer the negative effects of poverty on executive functions.

Currently, multiple schools in the United States have recognized the positive effects of physical activity on education outcomes and have adopted a sport and physical activity-based curriculum, in addition to schools in this study. Girls Athletic Leadership Schools (GALS) in Denver, Colorado is a 6th-8th grade school that incorporates physical activity into the first 45 minutes of the school day. Additionally, teachers incorporate movement into their daily lessons, allowing students to move and interact during lessons. Urban Dove in New York, NY, is a K-12 school that also integrates sport and fitness into their curriculum, with each student having the opportunity to participate in 1-hour of sport and 1-hour of exercise every school day.

Schools have also partnered with sport-based organizations to provide quality sport and physical activity programming to their students. UConn Husky Sport is a campus-community partnership that utilizes the power of sport to connect and empower partners from the city of Hartford, CT and the University of Connecticut. UConn Husky Sport implements in-school sport and physical activity-based programs in one K-8 school in Hartford, CT, providing approximately 30-90 minutes of sport and physical activity per week. Innovative approaches to school structure to incorporate greater sport and physical activity opportunities for youth in schools provide insight into how sport and physical activity can be used to engage youth and positively impact health and education outcomes.

Another strategy that school administrators and teachers have used to incorporate more opportunities to engage in physical activities during the school day, while not changing the school structure, is to integrate physically active lessons into the curriculum. The physically active lessons differ from traditional recess or brain breaks, which encourage physical activities apart from academic enrichment. Physically active lessons incorporate physical activity as a way to further engage students and teach academic content. Studies have revealed a wide range of benefits with incorporating physical activity into the teaching of academic content. Physically active academic lessons have been shown to not only increase physical activity levels among participants (Donnelly et al., 2009; Erwin, Abel, Beighle, & Beets, 2011), but have also shown to improve on task behavior (Grieco, Jowers, & Bartholomew, 2009) and academic achievement (Donnelly et al., 2009; Reed, Einstein, Hahn, Hooker, Gross, & Kravitz, 2010). Incorporating physical activity into daily academic lessons requires adequate time to be given to train teachers to learn how to develop optimal physically active lessons. Whether this training is performed in teacher preparation programs at the university level or in school level professional development contexts, incorporating physical activity into daily lessons may be another viable strategy to potentially benefit health, education and cognitive outcomes among youth in poverty.

With youth being required to spend approximately 8 hours a day, for 180 days in a school setting per year, incorporating greater physical activity opportunities into the school day is an approach that can reach a great number of youth and may contribute to sustained impact on health and education outcomes. Nevertheless, the school setting is merely one factor within the microsystem of youth. Another factor in the microsystem that must be considered is the availability of physical activity opportunities in the immediate neighborhoods and communities among youth in poverty. Among urban and rural youth in poverty, barriers to physical activity participation such as the distance to recreation centers, the associated costs, and the exposure to danger and crime have been reported (Moore, Jilcott, Shores, Evenson, Brownson, & Novick, 2010). A strategy to overcome these perceived barriers to physical activity participation in communities of poverty can include developing accessible recreation centers, with limited to no fees required for membership. While this avenue may not be cost-effective from a business standpoint, eliminating the location and cost barriers within the immediate community, increases access to physical activity and may encourage greater physical activity participation among youth in poverty.

The lack of "green" space in urban communities has also been associated with physical inactivity among urban populations (Hunter, Christian, Veitch, Astell-Burt, Hipp, & Schipperijn, 2015). Novel interventions of developing green space in urban communities to encourage physical activity participation have been promising, with the development of green space combined with physical activity programs being associated with greater physical activity levels (Hunter et al., 2015). Therefore, developing physically and economically accessible spaces to participate in physical activity programs within communities of poverty, can be another way to promote physical activity participation in the microsystem of youth and potentially improve cognitive outcomes.

Other important factors within the microsystem of youth that should also be considered are the support of peers and family members that can act as potential barriers or facilitators of physical activity participation. Among youth in poverty, peer support was reported as a facilitator of physical activity (Moore et al., 2010; Prochaska, Rodgers, Miki, & Sallis, 2002; Wilson, Pfeiffer, Evans, Williams, & Pate, 2004). This further reveals the importance of the quality of physical activities and their role to foster positive peer relationships. Furthermore, research also reveals that physically active parents are more likely to have physically active children and that parental support of physical activity increases physical activity levels among youth (Beets, Cardinal, Bradley, & Alderman, 2010; Rodrigues, D., & Machado-Rodrigues, 2018). Therefore, strategies to increase overall physical activity among youth should also include approaches to directly engage parents and family members in physical activities with their children. Providing quality sport and physical activity programs that foster positive peer relationships, as well as involving the family unit in the programs can be a unique way to support greater physical activity within the microsystem of youth in poverty.

Increasing opportunities to participate in quality physical activity and sport programs within every facet of the microsystem among youth in poverty can help promote positive health, cognitive, education and life outcomes. Incorporating physical activity programs into the school day, school lessons, neighborhoods, communities and families, provides a unique and comprehensive ecological approach that may foster positive health and cognitive outcomes among youth in poverty. Yet a word of warning is warranted for administrators, teachers, coaches and practitioners who desire to apply the findings of this research within communities of poverty. It is a false and widespread belief that mere sport participation inevitably contributes to positive youth development and that sport or physical activity are the solution to larger societal and systemic issues like poverty and education outcomes (Coakley, 2011). It is of utmost importance to acknowledge that the health, cognitive, and education disparities that are currently present in the United States, are largely due to the historical systemic oppression that groups in poverty have experienced. Even though the findings in this study are exciting, they should not be treated as the panacea to poverty and the negative outcomes associated with it. Increasing physical activity participation among youth in poverty is merely a temporary mechanism that may buffer the negative effects of living in poverty, within a larger system of oppression. Physical activity participation by itself cannot address the larger societal issues in the mesosystem, exosystem and macrosystem that are causing the disparities in health, cognition and education. Only when the larger systemic and structural issues that are causing oppression are addressed, will these disparities in health, cognition and education begin to cease. Therefore, increasing physical activity and sport participation within the microsystem of youth should be applied in context of the entire ecological systems model and should not be treated as the cure to poverty in society.

Another important implication from this study is that increasing opportunities within the factors of the microsystem of youth may not directly cause greater levels of physical activity. This is exhibited with the PAQ-C data among schools A, B and C. While there was a statistically significant difference in PAQ-C scores between school A (90 minutes of in-school physical activity and 120 minutes of after-school sport) and schools B and C (45-50 minutes of in-school physical activity, limited after-school sport), it was not absolutely indicative of physical activity participation among youth. There was a substantial amount of crossover in activity status, regardless of greater or more limited opportunities for sport and physical activity among participants in all schools. Twenty-three percent of participants in school A were categorized as inactive, even though all participants had the option to engage in 90 minutes of in-school physical activity and 120 minutes of after-school sport. Moreover, 45% of participants in schools B and C were considered active, despite the limited opportunities to engage in in-school physical activity and after-school sport. This finding further supports the adapted ecological model that was developed for this study (see figure 2), revealing other internal and external factors that may be contributing or mitigating sport and physical activity participation among youth.

This crossover of participants, despite their limited or greater opportunities, grants insight into other individual factors that may be enhancing or dampening perceptions and motivations to engage in physical activity. This is important, especially for teachers and administrators who may be encouraged to use the findings of this study to promote greater physical activity among their students in schools. Teachers and administrators must be aware that not all students, when given the opportunity will choose to be physically active. Due to a number of potential variables like a lack of enjoyment, self-confidence, self-efficacy, self-confidence and peer relationships, students may opt out of being physically active. In order to derive the prospective benefits from physical activity participation, school personnel should conduct student surveys or polls to assess if their students would be interested and thus potentially benefit from such participation.

Future Research

The findings in the current study present exciting opportunities for future research concerning physical activity participation on executive functions and stress regulation among youth in poverty. While positive outcomes on executive functions and stress regulation have been reported among more physically active youth in this study, a paucity in research remains concerning the type and quality of activity that youth are participating in that may be contributing to these positive outcomes. Moreover, future research should be conducted that distinguishes sport participation from physical activities, and their respective roles in affecting executive functions and stress regulation. This is an opportunity for sport management professionals, specifically sport-for-development researchers and practitioners, to assess the different types of sport and physical activities, as well as their program elements that may be associated with executive functions and stress regulation. Previous research has shown how mere rote exercise without cognitive engagement does not improve executive functions outcomes (Diamond & Ling, 2016), which points to other elements present in sport and physical activities can enhance executive functions. More research examining the quality of program elements of sport and physical activity such as peer relationships, the dyad between coaches and youth, coaching styles, and the types of sport and activity are needed in order to fully elucidate the program mechanisms that may be causing positive outcomes on executive functions and stress regulation.

Once the types and the quality of sport and physical activity have been identified, randomized controlled trials should be conducted in order to determine the causal relationship between sport and physical activity and executive functions. Developing and implementing quality sport and physical activity interventions among youth in poverty would grant greater insight and support into the role that sport and physical activity has on executive functions.

Further opportunities exist to examine physical activity participation and chronic stress among youth in poverty. In this study two saliva samples were collected daily, which only provided a glimpse into a half-day of a participants' cortisol levels. Conducting future research where multiple saliva samples, over multiple days, are collected from each participant would provide greater insight into chronic stress levels and the role physical activity among youth living in poverty. Collecting multiple samples over an extended period of time may also provide insight into the stress levels of youth living in poverty, and the various experiences that may impact stress regulation.

More research should also be conducted to examine why some youth choose to participate in sport and physical activity, despite having limited opportunities and why some youth opt out of sport and physical activity, regardless of greater access to sport and physical activity. Future research should further examine the individual factors that contribute or reduce perceptions to sport and physical activity participation. Subsequently, more research must be performed to assess which factors and perceptions mediate sport and physical activity behavior. Additionally, in-depth qualitative research should be performed to assess the different life experiences or influences among youth in poverty that may have shaped the positive or negative inclinations to sport and physical activity participation. Conducting this line of research can further expand the knowledge base of why youth participate or refrain from sport and physical activity. Teachers, administrators and sport managers would benefit from this research, allowing them to address the barriers and enhance the facilitators to participation. Improving youth perceptions can enrich participation levels, which may lead to the positive benefits of sport and physical activity participation on executive functions.

Limitations

Limitations to the study exist that should be acknowledged. Firstly, this study utilized a cross-sectional study design making it susceptible to threats of internal validity including the threats of selection and history. Selection may have been a threat to this study if students who opted into the study were primarily those who participated and enjoyed physical activities. Collecting and analyzing their physical activity frequency on the PAQ-C survey helped alleviate this selection threat to internal validity, revealing a significant number of participants who were categorized as inactive by the PAQ-C summary score (n = 60). Also, students who may have opted out of the study may actually be students who are experiencing greater adversity in their home life. The process of having parents/guardians sign and complete permission forms in order to participate in the study, assumes that parents/guardians are present and involved in the child's life at home. By potentially excluding certain students by requiring a signed permission form may hinder the insight concerning students who are experiencing great adversity.

Another threat to internal validity in this study was the threat of a participant history. No data were collected on the amount of family/guardian involvement, other program involvement in the community (e.g., church groups and community based programs), nutrition, amount of sleep, and the potential changes during the course of this study, which can significantly exacerbate or attenuate salivary cortisol and executive functioning outcomes. Another limitation to this study is the matching variable of poverty status among the three school sites. It cannot be assumed that all living in poverty are having the same experiences, regardless of differences in race, nationality, and region. Therefore, generalizability is limited to 5th-8th graders in the two regions; the Northeast region of an urban city in Connecticut, and the Southwest region of an urban city in Arizona. More research is needed to elucidate the diverse experiences of individuals living in poverty across racial and regional groups, which may affect executive functions and stress regulation. Lastly, this study was not able to control for all of the socio-structural inequalities among these racial groups that also may cause elevated levels of stress among youth in poverty.

There are also limitations to the internal validity of the salivary cortisol data collection and the PedsQL, PAQ-C and GaBSCI surveys. While study methods were implemented to ensure participant compliance during the home sample collection, there is no guarantee that all samples were taken during the recommended time frame, potentially significantly affecting the amount of salivary cortisol present in the sample. Furthermore, only two samples in one day were collected for each participant, potentially limiting insight into the full scope of a participant's cortisol profile. Students may have had a unique day, either stress relieving or stress inducing, on the day of sample collection, therefore skewing the results in this study. Additionally, a lack of a pre-existing relationship between the researcher and participants in school A and C, may have impacted the nature, type and quality of responses on the PedsQL, PAQ-C, and the GaBSCI. Due to the researcher being an "outsider" to schools A and C, participants may have been less honest and may have been subject to social desirability regarding their responses on the surveys.

Conclusion

Despite the limitations that may have been present in the current study, the combination of design and statistical controls utilized mitigated the confounding of the potential threats to the significance of the findings. Therefore, the findings provide sufficient evidence that greater physical activity participation is positively related to greater executive functions among 5^{th}-8^{th} grade youth in poverty. Notably, greater physical activity participation may act as a buffer to the adversity experienced by youth poverty and is related to greater working memory. Identifying the positive role of physical activities on cognitive development allows practitioners, administrators, and policy makers to support quality programs to foster optimal health and education outcomes among youth in poverty.

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Appendix

School Climate Survey

How do you feel about your school? Please answer each question honestly and circle the answer that best describes ***your*** feelings about school. There are no right or wrong answers. This is not a test.

1. I like school	Always	Sometimes	Never	
2. I feel successful at school	Always	Sometimes	Never	
3. I feel my school has high standards for achievement	Always	Sometimes	Never	
4. My school sets clear rules for behavior	Always	Sometimes	Never	
5. Teachers treat me with respect	Always	Sometimes	Never	
6. The behaviors in my class allow the teachers to teach	Always	Sometimes	Never	
7. Students are frequently recognized for good behavior	Always	Sometimes	Never	
8. School is a place at which I feel safe	Always	Sometimes	Not really safe	No-its dangerous
9. I know an adult at school that I can talk with if I need help	Always	Sometimes	Never	

Pubertal Observation Maturation Scale

<u>Thank you for participating in our study. Please place a check or mark by the characteristic that you have observed from your child.</u>

Females Characteristics Checklist:

______ The adolescent has grown 3 to 3.5 inches in the past 6 months or is past this growth spurt.

______ The adolescent has begun breast development. The adolescent has begun menarche.

______ The adolescent has evidence of darker underarm hair or shaves.

______ The adolescent has evidence of darker hair on her legs or shaves.

______ The adolescent’s calves are becoming defined.

______ The adolescent has evidence of acne.

______ There was evidence of sweating after physical activities.

Male Characteristics Checklist:

______ The adolescent has evidence of darkening of facial hair or shaves.

______ The adolescent's voice has gotten deeper or is currently breaking.

______ The adolescent has grown 3 to 4 inches in the past 6 months or is past the growth spurt.

______ The adolescent has darker hair on his legs. The adolescent's biceps are becoming defined.

______ The adolescent's calves are becoming defined.

______ The adolescent has evidence of acne.

______ There was evidence of sweating after physical activities.

______ There is darkened underarm hair.

Focus Group Questions

How do you feel about your school?

Why do you feel that way about your school?

What's your favorite part of your school?

Why is that your favorite part of school?

How do you feel about your teachers?

Why do you feel that way?

What can your school do to make you enjoy school more?

Student focus groups. To gain further insight into various student experiences within the school setting, semi-structured focus groups for each grade level were conducted at each school (Total = 12). Conducting focus groups with students allowed for a deeper analysis of the various experiences that have taken place within school that may affect stress regulation and perceptions of school climate. Participants were randomly selected from the total group of participants at each grade level using computer software, with each focus group containing 4-6 students. Students were asked about their feelings towards the school, teachers, and peers, and were asked to share specific experiences in the school that may have shaped their feelings. Questions such as: How do you feel about your school? Why do you like/dislike this school? What is your favorite part of your school? Why is that your favorite part of school? How do you feel about your teachers? Why do you feel that way? Why do you feel at ease/anxious at school? What can your school do to make you enjoy school more? All focus group interviews were audio recorded and then transcribed by a professional transcription service.

Focus Group Interviews

A total of 12 focus groups, with one for each grade, across each school (school A = 4; school B = 4, school C = 4) were analyzed. A total of 54 participants were selected to participate in the focus groups (school A = 22 students; school B = 17 students; school C = 15 students). The average time for each grade level focus group across schools was 13 minutes for the 5th grade, 10 minutes for the 6th grade, 14 minutes for the 7th grade, and 26 minutes for the 8th grade. 22 participants were females and 32 were males. The student researcher utilized computer assisted data analysis software (NVIVO) to code focus group data into a-priori themes. Comments were coded into cases supporting the quantitative findings regarding the relationship between sport and physical activity participation and positive school climate, sport and physical activity participation fostering positive peer relationships and the negative experiences of sport and physical activity participation. Additionally, comments were also coded into cases to garner more insight into the experiences of students that may explain the salivary cortisol outcomes. Therefore, the a-priori themes of negative interactions with adults in school, positive interactions with adults in school, negative experiences among peers and the negative experiences of 5^{th} graders were utilized.

Sport and physical activity associated with positive school climate. Across all focus groups, the availability of sport and physical activities in school, were mentioned as events that caused students or would cause students to appreciate school more. When students in school A were asked if they liked school, there was a consensus across all grade levels that they enjoyed coming to school and the cause of their enjoyment centered on their opportunities to participate in sport.

5^{th} grader: Now for me, it's all of the sports really. Like all of the different time periods, like after school, or at recess, and the variety of sports you get to play.

6^{th} grader: You get a win-win, cause you're learning and also playing sports in the school.

7^{th} grader: It's a good school and I like how they focus on sports and on education.

8^{th} grader: I like that we have workout, because I can't see myself not doing work out[s] now.

Students in schools B and C viewed access to more sport and physical activity as a component of school that would drive them to value school more. When asked about what the school can do to improve their perceptions of school, the students in schools B and C responded with more opportunities to participate in sport and physical activity.

8^{th} grader: "More activities. We could grab all the kids from the school and make them write down what they like. So if he likes soccer, I like football or I like sports, then make programs off of that. So it's going to be more motivating. Like oh, we're going to go to this program, I can't wait to go to that."

5^{th} grader: I wish this school had more opportunities, like playing some more sports.

Additionally, when asked a follow up question about why they liked school, students in school B mentioned their weekly participation in sport-based programming offered by a campus-community partnership fosters a greater appreciation for their school.

5th grader: Because of math, reading and 'Sport Hartford' (pseudonym). In other schools you don't get to have 'Sport Hartford'. This school is different because you get to do activities like after special. I like it when they do different things like baseball, volleyball and group activities.

8th grader: Sometimes, I like this school because like 'Mali' (pseudonym) said, different programs like 'Sport Hartford.'

8th grader: We finally get a chance to actually have fun instead of doing work all the time, because we need a good balance.

Sport and physical activity participation fostering positive peer relationships among peers. Sport and physical activities were also mainly viewed as avenues to develop and foster positive relationships among peers across grades and schools. When asked about why they liked participating in sports, their responses revealed how sport participation became a context to establish and develop friendships.

6th grader: We get to play with other people in our school and our friends and you get to also have an activity with these guys out of school and after school.

6th grader: You meet new people playing sports. That's how I met Archie (pseudonym).

5th grader: Sports is fun. We could get together and like spend time together and have fun.

7th grader: I kind of like coming to school because I get to see my friends. Also, I get to play with them. We get to play sports, and there's some sports that I haven't played until they came. The first time I started playing soccer was, I think, in fourth grade with her and volleyball with her. She was new to school and she didn't know anyone and she would play soccer. And so I didn't have anyone to play with and then we would play.

8th grader: And plus, we get to know each other a lot more. We get motivated, we have fun.

These opportunities for in-school sport and physical activity may help explain the positive relationship of sport and physical activity participation to the school climate survey. An additional point that was only observed among 8th grade students in school A, was a deeper bond formed among peers through sport participation. In addition to establishing friendships, students shared how sport fostered stronger relationships among peers.

8th grader: Somebody has your back, or like everybody from the team has your back.

8th grader: They're like a family.

8th grader: But then when you get into a sport, and you have like that little family.

This reveals how sport participation can be a context where youth can begin to develop empathy for one another and can foster a stronger sense of belonging.

Negative experiences of sport and physical activity participation. Even though positive aspects of sport and physical activity participation were mentioned across school types, only 8th grade students in school A shared negative perceptions of how sport engendered favoritism for "varsity athletes" among coaches and teachers. Favoritism by teachers and coaches was expressed through extra help with schoolwork, unwarranted increases in school grades, and the lack of discipline for negative behaviors.

8th grader: Yeah, favorites there you go. For us that don't play sports, it was like no, you're not gonna be able to get this grade back if you did bad already. But since they're in a sport, they can go to Saturday school and they get like a whole grade up. An F to a B.

8th grader: They don't treat me the same way they would treat a varsity player. Like I'm no one.

8th grader: And you can tell there's a big difference between a varsity player, or a person who does not play sports, because if you, like….Say the class gets in trouble, the favorites don't get in trouble as much as they do.

These comments show how special interactions between coaches, teachers and students, based on mere sport status, can cause negative feelings among peers. These negative feelings may play a role in school climate and the quality of life scores.

Negative Interactions with Adults in the School. Across schools A, B and C, participants shared negative interactions with teachers and coaches. These negative situations may be a factor in reducing the school climate scores, quality of life scores and may play a role in increasing salivary cortisol levels among students.

8th grader: She's always complaining that she has enough money, so it's not like she's doing this for money and always complaining, my kids are better than you guys.

8th grader: We had one teacher throw a chair. Yeah, she threw it at nobody, but yeah, she just grabbed it and threw it. She started screaming, she got red.

When students were asked about better strategies that teachers can employ to improve their relationships with students, they responded with simple methods.

6th grader: Stop yelling.

8th grader: Understanding more.

8th grader: I would tell them don't be judgmental or don't assume too quickly and try to see what's the issue and all that.

8th grader: Care more. I don't know, I feel like pay them more because maybe they'll start caring?

Applying the methods offered by the students may actually help improve perceptions of school climate and may also help reduce salivary cortisol levels among students.

Positive interactions with adults in the school. Across all schools, positive interactions with a wide-range of adults in the school were reported among students. These positive relationships were reported among teachers, coaches, janitors and school security personnel.

7th grader: Mr. G (pseudonym) is personally my favorite teacher cause he knows if I'm sad, he knows how to make me happy and stuff like that. He focuses on this and our education.

8th grader: I feel like the coaches don't give up, and they never give up on us.

7th grader: I like the teachers cause there are specific teachers where I can trust and tell things that are going on, and they can help me out with it.

8th grader: He would help us, like even though he was a janitor. He was nice. We still think of him as an important person in school. Like for example, when…like for me, when I had sports and my grades were down, I would have to do my work during lunch. He'll sit down and help me out. Like he would be like another teacher to me.

7th grader: He [security guard] just understands everything about us. Like in everything. Let's say something going on, and let's say you got a problem with a teacher and the teacher doesn't want to do anything. He always like just talk to us, like all chillax. You be okay.

Possessing positive relationships with adults in school may not only increase perceptions of school climate, but may also act as a buffer to decrease salivary cortisol levels among students.

Negative experiences among peers. Across all schools, frequent exposure to negative experiences such as bullying, fighting, and arguing were reported among students.

8th grader: No one likes each other. If it's an argument, it's a fight. They happen anywhere. They happen in the field, they can happen in the courts, they can happen in the classrooms and the restrooms.

7th grader: I'm in between because sometimes the environment is…most of the time it feels hostile. The kids, the fights, the loudness. There's a fight for every month probably.

8th grader: You got some girls like…You got the girls that just don't care, then you got the girls that just wanna start messing, causing problems, then they'll start with the girls that just laid back. And then it's like…then they wanna fight you and you be like…they be spreading rumors and all the crap that's been going down.

8th grader: Because kids just be so angry and just want to fight kids and all that.

Exposure to these negative experiences may decrease perceptions of school climate among students. Additionally, frequent exposure to such stressors may cause an increase in HPA axis activity, thereby increasing afternoon salivary cortisol levels.

Negative experiences of 5th graders. In two of the three focus groups for 5th graders, there were frequent references to bullying, teasing and fighting among their peers, when students were asked about what they would change about their school.

5th grader: The bullies.

5th grader: The fights.

Students were then asked regarding the frequency of exposure to these experiences and their responses coincided with once a week, across the focus groups only in school B and C. When asked regarding their feelings about these negative experiences, their responses included feeling annoyed, disappointed in their peers, and unsafe in the school. The exposure to the negative experiences of 5th graders in school and their associated feelings may help explain any differences of the P.M salivary cortisol levels, when compared to other grades.