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The University of Southern Mississippi

CIRCADIAN RHYTHM AND VIGOROUS ACTIVITY: DO THEY MAKE A  
DIFFERENCE IN EXECUTIVE FUNCTION?

by

Janie Sue Ryland

Abstract of a Dissertation  
Submitted to the Graduate School  
of The University of Southern Mississippi  
in Partial Fulfillment of the Requirements  
for the Degree of Doctor of Philosophy

August 2011

## ABSTRACT

### CIRCADIAN RHYTHM AND VIGOROUS ACTIVITY: DO THEY MAKE A DIFFERENCE IN EXECUTIVE FUNCTION?

by Janie Sue Ryland

August 2011

PL 107-110, the No Child Left Behind Act of 2001, a federally mandated accountability system based on standards, attendance, and dropout rates has forced educational leaders to explore new avenues of student improvement. Research suggests that all three factors are impacted by scheduling preferences that are relative to time of day. The aim of this study was to extend evidence of executive function as it is impacted by time of day and diurnal preference when exposed to vigorous exercise conditions. Data were collected from a sample that included 100 sixth graders (60 females and 40 males) during the spring semester 2011 from two southern parishes in Louisiana. Diurnal preferences were identified using the Morningness/Eveningness Scale for Children (Carskadon, Vieira, & Acebo, 1993). A pre-test and post-test of the Wisconsin Card Sorting Test- 64 (WCST-64) were performed during preferred and non-preferred times to indicate executive function changes. The post-test was performed after completion of the Multiple Level 20 meter shuttle run to simulate vigorous exercise conditions. A two-way ANOVA analysis with repeated measures on the WCST-64 did not yield any significant findings to support time of day or diurnal preference impact on executive function when exposed to vigorous exercise conditions.

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A Dissertation  
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## CHAPTER I

### INTRODUCTION

Sputnik's launch into space was not only a milestone in space exploration, but also a turning point in education. The educational system has traversed many avenues of change since the 1950s. The present phase of education is immersed in accountability. Society's demand for a better product is brewing among the stakeholders' quest for a reliable measurement of student performance. Standardized tests have rendered the answer for measurement in both reliable and validity constructs. Large-scale achievement tests, such as standardized tests required by No Child Left Behind, satisfy global estimation of learning, as well as depict aggregated levels of learning (Cizek, 2009). Large-scale tests have a reliability correlation of .90 or higher, signify that the scores on these tests are highly dependable (Cizek, 2009). Reliability is important, but the fundamental consideration of testing students' knowledge and skills is validity. Validity as defined by The Standards for Educational and Psychological Testing is the degree to which evidence and theory support the interpretations of test scores entailed by proposed uses of tests. The criteria of reliability and multi-dimensional validity (Goodwin & Leech, 2003) signifies the importance of relevance of fair instruments capable of assessing large quantities of data needed to satisfy stakeholders.

The financial restraints at all government levels require administrators to make determinations on which avenues contribute to improved academic performance (Geierstanger, Amaral, Mansour, & Walters, 2004). Due to No Child Left Behind, administrative responsibilities must include balance to ensure that students are receiving an overall education, yet are not "gaming" the accountability system (Figlio & Winicki,

2002). “Gaming” the accountability system involves student reclassification, scope reduction, cheating, student retention, and nutritional loading (Figlio & Winicki, 2002; Rouse, Hannaway, Goldhaber, & Figlio, 2007). Administrators have to find true means of increasing students’ performance within political constraints for the students’ overall well-being. Evidence provided by Rothstein and Jacobsen (2006) supports that biased testing toward math and reading scores is, in fact, enlarging the achievement gap for low-income and minority children due to lack of emphasis on other subject areas. This gap continues to widen because the increased emphasis on standardized performance scores has placed reductions and restrictions on the amount of physical activity time available to students (Geierstanger et al., 2004). Studies have shown that healthy children perform better academically (Geierstanger et al., 2004; Reed, Einstein, Hahn, Hooker, Gross, & Kravitz, 2010). A negative impact of unhealthy children, which can be directly related to reduce academic performance, is obesity (Patrick, Norman, Calfas, Sallis, Zabinski, Rupp, & Cella, 2006; Reed et al., 2010; Torre, Akre, & Suris, 2010). Alternative food choices and interactive physical environments will aid the students’ overall health improvement and thus the students’ academic performance (Torre et al., 2010).

The first task of administrators is to promote the connection between the importance of physical activity and academic performance. Stakeholders must be able to visualize the whole picture, instead of tunneling their vision on just standardized scores. Boredom and the lack of value are two avenues which hinder the student from taking advantages of the psychological improvements of sound physiological growth of improved performance in school (Saffici, 1999). Numerous studies have supported the physiological advantages the brain receives from stimulation from physical exercise

(Blaydes, 2001; Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Jensen, 2005; Shephard & Trudeau, 2005; Sohn, Chung, & Jang, 2005; Stevens, Yen, Stevenson, & Lochbaum, 2008). School administrators have the ability to provide a large number of children with the opportunity to use their mind and body to excel in the classroom. Reduction in recess, intramurals, and after-school activity programs has devalued the need for a healthy body, which in turn has decreased the students' academic performance.

The Center for Disease Control provides funding for education to combat obesity and physical inactivity both within and outside school time. Programs include improved nutritional programs and physical activity strategies for schools (Lee, Burgeson, Fulton, & Spain, 2007; Torre et al., 2010). The authorization by Congress of the Carol M. White Physical Education Program under Title X of the Elementary and Secondary Education Act provides administrators with an income source to promote physical activity in schools and communities (Lee et al., 2007). Suggestions for administrators to incorporate more physical activity include revamped school recess, walk and bike programs, intramural sports, physical activity clubs, interscholastic sports, and use of community facilities for physical activities (Lee et al., 2007). Administrators must consider the personnel hired as a physical education instructor and the goals the school wishes to obtain in delivering to the student all possible advantages to learning. School systems may further the advantages for students through incorporating, as California did, physical standards as part of their accountability requirements. An administrator's understanding of the brain and body's role in learning (Ploughman, 2008) will enable the individual to broaden his or her vision of education, thus enabling the student to continue to grow.

Other noted physiological aspects of importance for administrators are scheduling and start times. Evidence supports improved academic performance when academic stimulation corresponds with time of day preferences of the student (Folkard, 1979; Hines, 2004; Klein, 2004; Kubow, Wailstrom, & Bemis, 1999). The start time idea of one time fits all hinders the academic growth of the student due to fatigue and diurnal confusion. The creation of flexible scheduling would be more conducive to the natural learning environment of students. Adolescents tend to do better with later start times, whereas elementary students are more functional with earlier start times (Kubow et al., 1999). Class scheduling based on time of day of learning effectiveness is a more productive indicator of student academic success than technical placement (Ammons, Booker, & Killmon, 1995; Klein, 2004) based on the school rather than the student. Class performance based on the individual student's diurnal preference is improved by proper alignment. If overall class scheduling is unattainable, then another consideration for an administrator to achieve proper diurnal alignment for his or her students would be a rotating schedule with individual teachers to accommodate proper learning alignment (Ammons et al.; 1995).

Administrative choices for recognition of the importance of diurnal preferences and circadian rhythm cycles are not solely based on local decision making. America is demanding for change in its educational system, but may not be as accepting of change once the effects begin to filter down the system. Administrative change toward diurnal preference and time of day learning will require a huge effort by all stakeholders. Changes in school scheduling will require a layered effect to convince the public and state and local governments of the need and importance of changed starting times

(Hansen, Janssen, Schiff, Zee, & Dubocovich, 2005). These changes will affect not only daily school routines, but also after-school activities and sporting events (Hansen et al. 2005). The next stakeholders of interest are parents and school bus companies. Evidence suggests that parents prefer start-time which coincides with the parent's work schedules, and bus riding time; whereas, personnel present a challenge for educational change in school start and end times (Hansen et al., 2005).

The question arises then: Are the benefits of time scheduling worth the amount of effort needed to enforce change? The major components of No Child Left Behind hinge on improved standardized scores, attendance, and dropout rates. Studies show all three are positively impacted by scheduling delays (Wolfson & Carskadon, 2005; Wolfson, Spaulding, Dandrow, & Baroni, 2007). Wolfson and Carskadon (2005) offered school administrators a list of recommendations, such as educating the community, district-wide stakeholder assessments, school scheduling options, sleep evaluations relating to student absenteeism and attention deficiency, sleep curriculum, decreased homework, controlled end times for afternoon activities and athletics, family counseling, control of adolescent employment hours control, and a positive attitude toward sleep.

On a smaller scale, schools can consciously take into account time of day and diurnal preference to ensure that the students receive the best possible opportunities to learn. Standardized testing can be delayed from early morning starts to later preference times (Hansen et al., 2005). Block scheduling and priority scheduling would help to accentuate the student's prime learning time. Identification of optimum learning times and flexibility are key components that administrators will need to adopt in order to create change associated with time of day and diurnal preference.

Opportunities provided by No Child Left Behind have presented researchers with an extensive database of information in which to expound on the indices that are affecting student performance. External and internal influences have been proven to have some effect on student performances. Such influences as poverty (Payne, 2009; Tuerk, 2005), teacher quality (Darling-Hammond, 2000; Sanders & Horn, 1998; Tuerk, 2005), distribution of resources (Eisele, Eisele & Thomsom, 2009; Tuerk, 2005), and motivation (Ames, 1992; Amrein & Berliner, 2003) are a few possible indices for poor student performance. These components maintain emphasis on psychological and cognitive approaches to increased student productivity. The following paragraphs point to an emphasis on a different perspective directed toward a physiological approach to improved academic performance, specifically, executive function.

The United States Department of Health and Human Services disclosed the new physical activity guidelines with full support of the American College of Sports Medicine and American Heart Association detailing the need for children and adolescents (aged 6 to 17) to participate in one hour or more of moderate or vigorous-intensity aerobic physical activity per day. Activities from the American Heart Association that reach vigorous activity levels include brisk walking, hiking, stair climbing, aerobic exercise, running, biking, swimming, soccer, and basketball. Activities that are considered to moderate exercise by the American Heart Association include dancing, tennis, racquetball, and touch football. The guidelines recommend that an individual should participate in exercise that promote muscle-strengthening and bone-strengthen activities at a vigorous-intensity level at least three times in a week, (Jonas, 2009; United States Department of Health and Human Resources, 2008).

It is a proven fact that a healthy body promotes a healthy mind (Hertzog, Kramer, Wilson, & Lindenberger, 2009); therefore, continuous exercise augments brain health (Dishman et al., 2006). The cumulative effect of exercise triggers neurobiological stimulation and communication resulting in increased neural growth, thus increasing cognition. Repetition and association help the brain delineate information into memories to be later regurgitated for more complex learning activities. The intertwining of those experiences, combined with meaning, creates an environment for learning as parts and wholes work simultaneously to organize information (Caine & Caine, 2002). The formation of new experiences, combined with old events, allows the brain to be altered by those experiences (Jensen, 2005). Neuroplasticity enables the brain to reshape and reorganize the brain network based on neurological pathway usage (Willis, 2008). Reinforced stimulation accentuates the neuron viability and prunes experiences lacking in reinforcement.

The oxidative breakdown of glucose initiates fuel for neural response to ignite cognitive functions. The enhancements of oxygen levels increase frontal lobe activity, suggesting that higher concentrations of oxygen levels will enhance neural activity, which, in turn, will expedite cognitive performance (Sohn et al., 2005). The increased level of breathing, oxygen exchange, produced by vigorous exercise increases the amount of stale oxygen exchange, therefore decreasing lapse in concentration and memory problems (Blaydes, 2001). Blood flow is increased during vigorous exercise, integrating the brain hemispheres for more cohesive learning (Blaydes, 2001).

Vigorous activity is linked to indices that enhance neuronal activity which improves cognitive performance. Vigorous activity, in relative intensity, is sustained in



physical activities which exhaust 60% to 84% of a person's aerobic capacity. Supportive studies link vigorous activity to improved academic performance (Coe et al., 2006; Shephard & Trudeau, 2005; Stevens et al., 2008). A relationship is observed between intensity of exercise and higher-order cognitive measures (Chang & Etnier, 2009). Complex decision making can be associated with frontal lobe activity involving a cognitive ability of executive function. Executive function involves the abilities of inhibitory control, planning, cognitive flexibility, error correction, and detection (Dempster, 1992; Welsh, Pennington, & Groisser, 1991; Zelazo, Carter, Reznick, & Frye, 1997). The physical stimulation of the executive function abilities draws reference to the possibility of improved cognitive performance related to 21st century learning skills.

The complex multi-task aspects of executive function are situated more physiologically through adverse differences in diurnal preferences, which are related to the intrinsic period of the biological clock (Duffy, Rimmer, & Czeisler, 2001; Groeger, Viola, June, von Schantz, Archer, & Dijk, 2008). Misalignment of circadian rhythms can cause alteration of blood flow, which adversely affects the prefrontal brain region causing neural changes in task related performance (Blatter & Cajochen, 2006; Bratzke, Rolke, Steinborn, & Ulrich, 2009; Groeger, 2008). The impairment of neuropsychological performance through circadian rhythm modulations hinders task related to higher-order thinking (Taras & Potts-Datema, 2005). The hindrance implies that sleep deprivation impacts executive function abilities. This hindrance can be related to performance in the classroom depending on testing related to the individuals' diurnal preference. Students with irregular sleep patterns, reported lower academic grades than students with regular sleep patterns who received higher performance marks (Wolfson &

Carakadon, 1998). This leads to the observation that time of day is interrelated to the optimal performance of the individuals' maximum abilities. The level of effectiveness rises when the instruction corresponds with the individuals' diurnal preferences of proactive thinking (Kirby & Kirby, 2006).

Another physiological aspect of interest affecting circadian rhythm is core body temperature. Core body temperature is a phase marker for determining circadian rhythm. This avenue will not be presented in depth, but is mentioned due to the physiological relationship of the exercise and core body temperature. Exercise by nature raises the core body temperature in which physiological adaptation of cerebral body flow applies adjustments to the brain to reestablish the temperature through heat removal (Nielsen & Nybo, 2003). In addition, different intensity levels and duration of exercise can impact phase shifts associated with circadian rhythm (Edwards, Reilly, & Waterhouse, 2009) that relate to optimal diurnal times for performance.

Work in neurogenesis ties the aspect of physiological changes of neural activity to exercise, which can also be associated with physiological changes pertaining to circadian rhythm. Exercise increases the number and growth of newborn neurons which increases cell genesis that is associated with enhanced hippocampus synaptic plasticity (van Prang, 2008). A detected correlation between the stimulated running area and synaptic plasticity (van Prang, 2008) suggests that neuron strength may improve forms of cognition.

### Problem Statement

The primary focus of this study was to extend the examination of the relationship of circadian rhythm under vigorous activity conditions in order to determine the possible influence on executive function in this relationship. This casual comparative study was

designed to focus on the effect of individual diurnal preferences on executive function when exposed to vigorous exercise conditions. Physiologically, the body is designed to metabolize glucose received from cerebral blood flow to provide fuel that the body can use for functions, specific to this study, executive functions. The intensity of exercise increases the need for oxygen; therefore, increased cerebral blood flow is needed to sustain the body's equilibrium. The level of oxygen content will be measured as a subtest to draw conclusions on the saturation of oxygen in the body related to improving cognitive abilities. High densities of neurons formulate to contribute to increase frontal lobe activity stimulating memory, thought, and abstract reasoning. Short-term memories, which last approximately 18 seconds, are affected by long-term potentiation causing changes in the neurons, which store long-term memories based on viability of reinforcement and pruning. Brain-based learning maintains that the brain has the capability to use experiences based on synaptic plasticity to increase neuron connections; thus, this concept promotes the ideas of increased executive abilities.

The body's interpretation of circadian rhythm establishes patterns of morningness and eveningness which are believed to affect cognitive performance. The misalignment of diurnal preference interferes physiologically with the individual's ability to perform at optimal cognitive levels. The identification of the individual's natural patterns of optimal cognitive timing for retention and learning will enable school systems to tap into the most desirable attributes of the specific student. The misalignment of the intrinsic period of the biological clock can be assisted by a phase marker, core temperature, which could be altered due to an increase in exercise intensity.

The constraints of No Child Left Behind require new avenues of improved performance which are necessary to meet the needs of the 21st century learner. The correlation of the vigorous physical activity associated with preferred time of day may expose a positive effect on higher-order skills vital to the global learner of this age. The physiological changes created through vigorous physical activity may intertwine to create a more efficient machine of learning.

This study will provide feedback to lawmakers, the leaders in the State Department of Education, the Office of Public Health, and school personnel in the public school systems to determine if school day timing or diurnal preference timing could be impacted through intensity levels of physical activities in order to accentuate executive function abilities for improved 21<sup>st</sup> century skills of learning. Students were administered a morningness/eveningness survey to determine diurnal preferences. A pre-test of the Wisconsin Card Sorting test established a baseline for executive function. On a separate day, individuals were categorized into optimal diurnal preference and nonoptimal diurnal preference groups and administered the multi-level shuttle run. An approximation of exercise intensity was determined from the individual's estimated maximum VO<sub>2</sub> uptake using the David Swain formula. These individuals were readministered the Wisconsin Card Sorting Test to determine the influence of diurnal preferences and vigorous activity on executive function.

#### Research Questions

1. Is executive function affected by testing time alone when exposed to vigorous intensity levels of exercise?

2. Is executive function affected by individual diurnal preferences (morningness/eveningness) when exposed to vigorous intensity levels of exercise?
3. Is executive function affected by the interaction of testing time and morningness and eveningness when exposed to vigorous intensity levels of exercise?

### Definitions of Terms

*Executive function* - Executive function is a higher-order cognitive ability that controls basic, underlying cognitive functions for purposeful, goal-directed behavior and that has been associated with frontal lobe activity (Etnier & Chang, 2009).

*Circadian rhythm* - Circadian rhythms are physical, mental, and behavioral changes that follow a roughly 24-hour cycle, responding primarily to light and darkness in an organism's environment (National Institute of General Medical Sciences, 2008).

*Morningness/Eveningness* - This phenomenon refers to sleeping habits where morning people wake up early and are most alert in the first part of the day and evening people are most alert in the late evening hours and prefer to go to bed at a later time.

*Diurnal preferences* - Diurnal preferences are attributes of animals and human beings reflecting at what time of day their physical functions (hormone level, body temperature, cognitive faculties, eating, and sleeping) are active, change, or reach a certain level.

*Vigorous exercise intensity* - Vigorous exercise intensity is defined relative to fitness, with the intensity expressed in terms of a percent of a person's maximal heart rate, heart rate reserve, or aerobic capacity reserve depleting 60 to 84% of the reserve (Physical Activity Guidelines for Americans, 2008).

### Delimitations

The following delimitations were applied to this study. The study was limited to two Southern Parishes in Louisiana. Participants were obtained from grade 6 only. The participants were recruited in the winter and spring of 2011. The study did not delineate between genders or socioeconomic status. The individuals' body mass or fitness level was not considered in this project, although this could possibly impact the participants' performance levels in the multistage 20 meter shuttle run, thus impacting the vigorous exercise component. The differences in surface levels could pose a problem due to slippage, thus causing the participant to not reach the cones in the allotted time needed to continue the multi-level 20 meter shuttle run. Core body temperature was not measured due to the intrusiveness of the process in this study but bears mentioning because core body temperature will be raised due to exercise. Practice effect on the Wisconsin Card Sorting Test has to be considered in this study due to the proximity of testing days. Student bedtimes and self-reporting could possibly have an effect on the score of the Morninness/Eveningness Scale for Children Questionnaire.

### Assumptions

The following assumptions served as the basis of conduct for this study. An assumption was made that all participants completed the Morningness/Eveningness Questionnaire and Wisconsin Card Sorting Test 64 based on all of their knowledge base. Also assumed is that all participants completed the Multi-Level Shuttle Run based at their highest level of physical achievement.

## Summary

No Child Left Behind's restricted view of educational value limits administrators to creating learning environments conducive to increased academic growth based on financial and political considerations more so than student-centered performance indicators. This chapter introduced the prospect of intertwining the physiological and psychological components of an individual to increase overall learning potential. This relationship is introduced by focusing on the effect of individual diurnal preferences on executive function when exposed to vigorous exercise conditions. The research design incorporated the Morningness/Eveningness Scale for Children Questionnaire (Carskadon, Vieira, & Acebo, 1993) and the Wisconsin Card Sorting Test 64 (Cianchetti, Corona, Foscoliano, Contu, & Sannio-Fancello, 2007; Feldstein, Keller, Portman, Durham, Klebe & Davis, 1999; Lemmink, Visscher, Lambert, & Lamberts, 2004; Vayalakkara, Devaraju-Backhaus, Bradley, Simco, & Golden, 2000) to determine the relationship. Vigorous exercise conditions were created using the Multi-Level 20 Meter Shuttle Run (Aziz, Tan Jun Yau, & Teh Kong, 2005; Lemmink et al., 2004; Ortega et al., 2008; Paliczka, Nichols, & Boreham, 1987).

Exercise triggers neurological stimulation, which affects complex learning activities, as well as impacts individual phase changes that optimize performance. Vigorous activity intensity levels and identification of diurnal preferences enable the learner to tap cognitive functions through psychological and biological processes. The cumulative effect of body and mind presents educational leaders with a different perspective to optimize the 21<sup>st</sup> century learner.

Administrative challenges comprise stakeholder support, scheduling of classes and buses, and resource manipulation. Research supports the value of meeting these challenges because of the positive impact on academic scores, attendance, and dropout rates (Wolfson & Carskadon, 2005; Wolfson et al., 2007). This chapter provides an overall summary of the position of this study to combine the physiological and psychological components of learning for growth in the 21<sup>st</sup> century to challenge the need for change in the educational system.



## CHAPTER II

### REVIEW OF THE LITERATURE

#### Educational Reform

The Sputnik era of educational reform was initiated because public perception of education was tainted by this country's lack of supremacy on the world stage. This turning point spurred the public drive toward increased federal aid, which was once a feared phenomenon. This unusually high demand from the public for increased federal aid initiated the passage of the National Defense Education Act in 1958 (Bybee, 1997). This era of education was based on fundamentals, scientific inquiry, and problem-solving.

*A Nation at Risk: The Imperative for Educational Reform* (1983) provoked the concept of the life-long learner. The next step was GOALS 2000, a bipartisan adventure between the Bush and Clinton Administration in 1994. This comprehensive approach was employed to help all students succeed in life (GOALS, 2000). The public was still not satisfied with the educational product, however; thus, the enactment of No Child Left Behind Act (NCLB) in 2001 became the new mode of accountability in educational reform with an emphasis on reading and mathematics. NCLB, even though steeped in conflict (Moon, Brighton, & Callahan, 2002), provides the public and political forums measuring sticks for educational reform. Research-based criticism admits that standardized test might identify schools that need help, but not the level of learning of these institutions due to test retakes (Lewis, 2001).

Once again, education is under fire to produce a marketable product to compete in the global market. The digital natives aspire for active interaction learning for world-

based jobs (Levine, 2010). The new wave of educational reform is based on neurological discoveries of learning patterns that will individualize learning for the 21<sup>st</sup> century learner. Whole body learning will be utilized with neuroscience advances in learning to create the learner of tomorrow.

### Theory Foundation

Factory-style education does not present a viable means of educating students in the 21st century. Education has evolved into a multi-dimensional approach incorporating the whole individual as a tool in the learning process. The focus of brain-based learning is a neurological approach which incorporates the brain as a parallel processor delineating information from the whole body to create applicable information strands through intrinsic learning. The body is a well-devised machine capable of synthesizing oxygen to obtain glucose for the production of ATP to fuel the body. The increase of intensity of exercise stimulates cerebral blood flow and glucose exchange producing neurological processes which promote cognitive functioning. The reduction of barriers in approximately the last 20 years between the field of psychology and the field of neurosciences has opened a new venue for educational discernment. In a constructive, active learning approach, educators can tap the vastness, complexity, and potential of the human brain (Caine & Caine, 2002). The need is for educators to tap the individuality of the learning complexities of each distinct brain and create a stimulus for interpreting and evaluating information for future use. Brain-based learning invokes self-directed learning from life experiences to seal the imagery in order to provoke brain stimulation through thematic grasp of the data.

Knowledge of the brain divides the brain into three main components: cerebrum, cerebellum, and the brain stem, which are divided into two hemispheres, left and right hemispheres. The basic constructs of the brain involve the left brain, which favors logical thinking, analysis, and accuracy. Tasks involving words, symbols, and numbers are familiar avenues for learning for the left-brain learner. Left-brain thinkers use facts to logically base conclusions. Right-brain learners, on the other hand, use thinking constructs from an aesthetic, feeling, and creativity prospective. Right-brain learners view tasks intuitively. These learners view tasks as the big picture. These findings of lateralization of the brain has drawn criticism recently from researchers who feel that categorization of the brain to hemispheres is too crude with the present information available (Bruner, 1999; Chabris & Kosslyn, 1998). Other skepticisms exist from the fields of neuroscience and cognitive psychology that believe that the craft of education of knowledge can be immersed in the scientific realm (Colburn, 2009; Willingham, 2008; Willis, 2008). A common point that all sides agree upon is that further research is needed to determine the correlations of neuroscience and psychology into the educational world.

The theory of brain-based learning Eric Jensen proposes fifteen core principles to guide learning. Written in summarization the principles are parallel processing, whole and parts simultaneously, multiple brain storage, whole body learning, innate meaning, patterning, emotions, meaning, focus attention, spatial and rote memory, natural spatial memory, social, enhanced by challenge and inhibited by stress, uniquely organized and learning is developmental. The assumption of this theory is the driving component in this study. Eric Jensen (1998) proposes a relationship exist between exercise and cognitive learning. Jensen associates new growth of neurons with memory capabilities. These two

concepts are proposed thoughts to associate physical activity to cognitive ability. A study by Caterino and Polak (1999) concluded an advantageous benefit to exercise to mental focus and concentration. Trois Rivières' study opened thought to the advantage of oxygen content even though this was not the specific function of the study.

The Multiple Intelligence theory reflects the idea individual possess varying abilities of preferred intelligence that are available for learning. The key is to unlock the intelligence to promote learning as a whole and not focus on one locality of the brain. The summarized version of the intelligence are as followed: linguistic intelligence (“word smart”), logical-mathematical intelligence (“number/reasoning smart”), spatial intelligence (“picture smart”), bodily-kinesthetic intelligence (“body smart”), musical intelligence (“music smart”), interpersonal intelligence (“people smart”), intrapersonal intelligence (“self-smart”), naturalist intelligence (“nature smart”) (Armstrong, 2000; Gardner, 1999). Individual possessing the intelligence of visual-spatial see the world in pictorial imagery. The concepts of drawing and puzzles provide mental stimulation. The intelligence of music excites the individual’s thought the use of rhythm and sound. The individual possessing understanding and socialization skills represents the interpersonal intelligence, but the individual capability of self-discovery possesses intelligence. A good grasp of words for expression falls in the category of linguistic intelligence. If calculating and reasoning is the learner’s strong suit then the individual possesses logical-mathematical intelligence. The last mention intelligence is bodily-kinesthetic. The learner possesses keen body awareness to engage in the learning process. Some misconception to Gardner’s Theory of Multiple Intelligence involved the confusion of learning styles, social domain, and music mastery (Gardner, 2003).

Brain-based learning and Howard Gardner's Multiple Intelligence Theory draw on the cumulative effects on the mind to formulate thoughts. The degree of stimulation and orchestration of affected dimensions within the brain cause delineation of ideas, provoking thoughts into actions and memory. Jensen (2005) reflected on the mind as a multi-dimensional assimilator of knowledge, whereas, Gardner (1993) reflected on specific sets of abilities associated with each of the intelligences. Resemblance of brain-based learning and multiple intelligences can be traced further to the work of Jean Piaget (1950). Piaget theorized that cognitive structures were formulated in response to physical experiences within the individual's environment in correlation to the individual level of development. Piaget's theory followed perceptual actions into mental thought progressing to logical concrete thinking and finally into formalized reasoning. The differences in the three theories brain-base learning, multiple intelligences and Piaget's theory lie in the degree of specificity, but have a generalized commonality.

The generalized commonalities of the theories are rooted in cognitive constructivism that is a construct recognized through the work of Jean Piaget. Constructivism is a philosophical belief that people construct their own understanding of reality (Oxford, 1997). Constructivists believe individuals derive meaning from experiences which are assimilated into valid gains of knowledge unique to the environment of the individuals. Piaget's thoughts on assimilation and accommodation reflect the need for the individual to transverse the information through stages of development to formulate cognitive thoughts based on new knowledge acquired in the process (Piaget & Inhelder, 1971).

The underlying roots of constructivism are embedded in two philosophical theories of knowledge: ontology and epistemology. Piaget's work reaches into the realm of epistemology, which focuses on the child's development and elaboration of schemata (Oxford, 1997). Piaget viewed the child as a lone scientist creating his or her own perceived world. The concepts of epistemology can be traced to a 17<sup>th</sup> century philosopher, John Locke, who viewed the mind as a blank slate on which ideas are imprinted from world experiences that were later constructed into more complex ideas. Questioning and answering did not stop with ideals of epistemology. Documentation by Plato reveals that inquiring and answering elements date back to the Greek philosopher Socrates. Socrates can be predated by the Greek Pre-Socratic philosophy that was, interestingly enough, comprised of physical or nature philosophers.

From as early as the fifth century, the concepts of environmental influences on brain imaging to create new pathways of thought have been evident. Early evidence from the Pre-Socratic and Socratic philosophy suggests that the effects of the physical environment have influences on inner experience reflecting the importance of why individuals learn (Piaget, 1973). Epistemology strives to promote foundation and validation of knowledge through experimentation. Locke viewed the mind as a blank tablet capable of assimilating environmental influences from simple constructs into more complex ideas. Piaget's theory recognizes the development of schemes in building cognitive structure through perceived environmental experiences. Howard Gardner specialized the cognitive indices into the multiple intelligence, which focuses on the individual aspects of learning abilities. Brain-based learning expands on the intelligence

while drawing reference to neurological and environmental components that affect the body as a whole (Jensen, 2005).

### Circadian Rhythm and Preferences

Circadian rhythm is a biological process, but the interjection of arousal through vigorous exercise combined with the biological process of diurnal preferences may show a correlation to diurnal effects on learning. The optimal time of arousal motivates cognitive changes toward learning. Individuals' circadian rhythms are physical, mental, and behavioral changes that follow a roughly 24-hour cycle, responding primarily to light and darkness in an organism's environment (National Institute of General Medical Sciences, 2008). According to the National Heart, Lung, and Blood Institute ([www.hhs.gov](http://www.hhs.gov)), children need 9 hours of sleep per night. In conclusions drawn by Thomas et al. (2000), sleep is the neurobehavioral index that restores cognitive dominance, alertness, and brain activity created from sleep deviation constraints. Evidence stresses the importance of required sleep for more accurate recall than those hours of just wakefulness (Ellenbogen, Hulbert, Jiang, & Stickgold, 2009). An interruption of the intrinsic circadian period affects the diurnal preference through misaligned waking times (Duffy et al., 2001). Studies have concluded an association between morning and evening affects hemisphere changes specific to the diurnal preference time (Folkard, 1979; Klein, 2004). The stimulation of the brain increases neuron receptors in the cerebral cortex. High densities of neurons formulate to contribute to increase frontal lobe activity stimulating memory, thought, and abstract reasoning. Short-term memories, which last only approximately eighteen seconds, are affected by long-term potentiation causing changes in the neurons, which store long-term memories.

The layering of the brain contains many neurons capable of synapse; one such layer is the hippocampus. The section of the brain referred to as the ancient cerebral cortex part, the hippocampus, affects brain functions associated with memory and spatial navigation. Brain-based learning maintains that the brain has the capability to grow neurons; thus, this fact promotes the concept of increased cognitive function. The body's interpretation of circadian rhythm establishes patterns of morningness and eveningness believed to affect cognitive dominance of brain hemispheres. The possibility of arousal patterns of the individual during segments of the day has a role interrelating the academic performance of the individual toward retention and memory. The natural circadian patterns of the individual are influenced by possible arousal points for the person. This influence may show a natural pattern of retention between long-term and short-term memory as well subject-specific timing.

Diurnal preferences are attributes of animals and human beings reflecting at what time of day their physical functions (hormone level, body temperature, cognitive faculties, eating, and sleeping) are active, change, or reach a certain level. Differences in intrinsic periods create a physiological index that portray diurnal preferences and wake times as potential underliers of morningness/eveningness (Duffy et al., 2001). Diurnal preferences can increase performance when phase changes related to core temperatures are in tune with those preferences (Baehr, Revelle, & Eastman, 2000). The concept of morningness/eveningness acts as an identifier for diurnal preferences such that morning individuals are apt to be early risers and evening individuals prefer the late hours (Carskadon et al., 1993; Wolfson & Carskadon, 1998). The lack of the identification of the psychological markers for each individual preference may actually be a hindrance if



“early to bed and early to rise” is not consistent with the individual’s diurnal preference (Carskadon, 1990). This makes the point of Wolfson and Carskadon (1998) that the primary concern should not be necessarily that a shift phase is occurring, but what implications are those changes having on the individual? Biological, psychological, and environmental differences should be considered in determining school start times and scheduling as cognitive performance barriers. The lack of consideration of the effect of sleep hindrance on performance would be a travesty of justice. Evidence for this negative impact can be seen in the tilt of falling grades that students experience due to misaligned sleep patterns.

Phase differences for morning diurnal preference individuals are related to waking in the middle of temperature minimums, which are at a point of need for decreased sleep and increased alertness and performance (Duffy et al., 2001; Johnson et al., 1992). The opposite occurs with evening diurnal preference individuals who wake at the end of the temperature minimums (Duffy et al., 2001). A synonymous relationship can be drawn for study between diurnal preferences and morningness/eveningness (Horne & Ostberg, 1977) depending on the context of referral in the research. Diurnal preferences of morningness or eveningness determine an individual’s performance levels based on the circadian rhythm patterns of that individual, even though the levels are independently or collectively affected by other biological and environmental factors not covered in this study.

## Biological Changes

The body remains in a state of heat gain in the morning and heat loss in the afternoon unless external forces of change are applied to accent these changes during circadian rhythm phasing. Exercise intensity levels can act as a zeitgeber causing changes to the endogenous molecular components of the 24-hour cycle (Edward et al., 2005). Thermoregulatory responses to exercise will induce accented changes in the core temperature (Drust, Waterhouse, Atkinson, Edwards, & Reilly, 2005). These changes are pronounced due to heat states relative to time of day and level of exercise (Waterhouse et al., 2005). The body's movement of blood to and from the surface and sweating help the body to maintain equilibrium. This manipulation of core temperature is affected by circadian phasing relative to the minimum and maximum rates of rise and fall during evening and morning states (Waterhouse et al., 2005). Body temperature will rise when exposed to strenuous exercise conditions causing metabolic heat production increases (Waterhouse et al., 2005). The rise in body temperature causes an increase in oxygen release to maintain equilibrium during conditions of increased metabolism.

Physiologically the body is designed to metabolize glucose received from cerebral blood flow to provide fuel that the body can use for functions, specific to this study, cognitive functions. The intensity of exercise increases the need for oxygen; thus, a needed increase in cerebral blood flow is needed to sustain body equilibrium. Bouts of exercise increase the availability of oxygen, glucose, and nutrients due to increased cerebral blood flow (Potter & Keeling, 2005). The more vigorous the intensity levels of the exercise, the greater the body's capacity for oxygen and glucose enrichment. These studies ascertaining increased physical activity and promoting high intensity will promote

physiology arousal of the body, causing increased brain activity. An increase in physical activity increases cerebral blood flow which, in turn, increases auto regulation, changes in diameter of blood vessels. The increased diameter of the blood vessel promotes an increase of blood flow to the brain. The increased blood flow accentuates an environment rich in oxygen and glucose. The cumulative efforts of oxygen and glucose produce energy. The oxidation of glucose creates an environment conducive to increased neurological messaging, thus promoting increased brain activity (American College of Sports Medicine, 2003; Berger & Jones, 2007; Herholtz et al., 1987; Moss, Scholley, & Wesnes, 1998; Pienaar, 2009; Querido & Sheel, 2007; Shephard & Trudeau, 2005; Sibley & Etnier, 2003; Sohn et al, 2005; Swain et al., 2003).

The intertwining effect of exercise and circadian rhythm on neurotransmitter levels creates an interdependence of the two components (Potter & Keeling, 2005). These chemical messengers transmit nerve impulses cross synapses. This transmission process requires high amounts of energy which is obtained from glucose that combines with oxygen to produce energy for the brain. ATP functions as a neurotransmitter for nerve cells and target cells as well as its function in metabolic energy releases. High densities of neurons store and process information for use in the frontal lobe to stimulate memory, thought, and abstract reasoning. Long-term potentiation increases synaptic strength with neurons, which underlies learning and memory based on reinforcement and pruning.

Exercise promotes neuron increases and morphology changes during cell genesis that enhance hippocampal synaptic plasticity (van Prang, 2008). Brain-based learning maintains that the brain has the capability to use experiences based on synaptic plasticity

to increase neuron connections. Physical exercise increases neurogenesis in the hippocampus through increased progenitor proliferation (Brown et al., 2005). These target cells are susceptible to neurotransmitters; therefore, increased synapses can occur. The increase in synaptic occurrence will promote enlargement of the synapses which can correlate to reinforcement of learning and memory.

Neurons collect memory traces from learned experiences to convert into memory. Neural circuitry aids in the transfer of memory traces into memory in the hippocampus. Past memory plays an active role in the formation of information patterns for future learning based on repetition priming (Race, Shanker, & Wagner, 2008). Working memory includes cognitive process such as executive function for completion of learning task associated with activation of the prefrontal cortex (Callicott et al., 1999). Executive functions optimize limited resource usage of cognitive resources for task performance while allocating continued exploration for change possibilities due to external factors (Mansouri, Tanaka, & Buckley, 2009). Exploration of new possibilities enables the mind to override habitual behaviors and formulate new solutions, and task switching (Mansouri et al., 2009).

### Executive Function

Executive function is a higher-order cognitive ability that controls basic, underlying cognitive functions for purposeful, goal-directed behavior and that has been associated with frontal lobe activity (Etnier & Chang, 2009). Executive function involves the abilities of inhibitory control, planning, cognitive flexibility, error correction, and detection (Dempster, 1992; Welsh et al., 1991; Zelazo et al., 1997). These multi-abilities involve overlapping and intertwining brain processes for completion of a task. The

division of executive function into sub-processes allows for recognition of the complexity of higher-order cognitive processes and their interactions (Zelazo et al., 1997). The explorations of those interactions enable the individual to prioritize the sub-processes to execute higher-order responses to the situation. The interjection of new traces of information enables the individual to override habitual responses and formulate different solutions to unfamiliar task (Mansouri et al., 2009). An individual immersed in the memories of the past who overrides future process decisions could have detrimental constraints on cognition, referred to as proactive interferences (Badre & Wagner, 2007). Proactive interferences could have deleterious effects on the executive function abilities of an individual in higher-order activities. The brain needs to recognize these detrimental demands and reorganize the sub-process and allocate more cognitive resources to overcome the hindrances (Mansouri et al., 2009).

The integration of the sub-processes creates flexible cognitive actions within the frontal, parietal, and striated regions that are central components of executive function (Badre & Wagner, 2007; Bunge & Wright, 2007; Crone, 2009). Between the ages of 8 and 12 years, children's levels of executive function are increasing based on the maturity of added neural circuits (Bunge & Wright, 2007). Improvement in executive function portrays a correlation between growth of neural processes and puberty maturation. The use of experiences creates a bank of knowledge based in memories that enables the individual to execute higher-order skills based on maturation level of executive function.

The stimulation of neurotransmitters during physical exercise creates psychological and physiological changes that can reduce the effects of circadian rhythm on cognitive performance (Potter & Keeling, 2005). The intensity level of physical

exercise is relevant to improved performance on execution function test (Davis et al., 2007; Tomporowski, Davis, Miller, & Naglieri, 2007). Evidence also suggests that the circadian clock affects the prefrontal component of decision-making which is considered an executive function (Valdez et al., 2005). Intensity levels of physical activity produce physiological changes on both circadian rhythm and executive function, thus promoting an outcome of improved cognition for higher-order skills. These correlations ignite the possibility that school schedule could be greatly impacted based on the individual's ideal physiological and psychological preference for learning.

The complexity of required executive function skill shows relevance to circadian phasing and cognition (Blatter & Cajochen, 2006; Taras & Potts-Datema, 2005). Interruptions of diurnal preferences from normal cycling will hinder the ability levels of cognitive processing. This hindrance may inhibit the true academic potential of the individual. In this age of standardized performance testing this hindrance will affect the outcome of scoring. The start time of schools and course scheduling (Davis, 2001) may be detrimental to obtaining the true academic potential of the individual (Klein, 2004). The possibility of circadian modulations related to prefrontal cortex functions decreases the potential of performance of higher levels of cognition (Blatter & Cajochen, 2006; Bratzke et al., 2009), thus decreasing the possibility of reaching true academic excellence.

Exercise produces physiological and neurophysiological changes toward improved psychological processes of executive function skills (Davranche & Audiffren, 2004). The arousal of the body and mind creates an atmosphere conducive to higher-level learning skills. The intensity level of exercise creates a neurophysiological state

that facilitates the complexity of the individual to engage in higher-order thinking (Davranche & Audiffren, 2004; Tomporowski, 2003). The more alert the mind, the more adaptive to igniting sub-processes to increase executive functions.

### Cognition and Circadian Rhythm

The impairment of circadian rhythm creates neuropsychological changes that impede higher-level cognitive functions (Taras & Potts-Datema, 2005). This raises the question of validity to changing start times of school or scheduling based on neuropsychological impacts on cognitive performance, specifically executive function skills. The psychological conditioning of intrinsic circadian rhythm and diurnal preferences are hindered by an individual's wake time related to the academic day (Duffy et al., 2001). Phase timing corresponds with core temperature minimums and desired alertness and performance (Duffy et al., 2001).

Physiological factors would show increased arousal, thus influencing the possibility of performance at optimal level related to the individual's arousal levels. According to Folkard et al. (1977), arousal performance may fluctuate throughout the day depending on the individual and arousal levels thus affecting recall related to morningness. This study observed 62 males and 68 females from parallel tutoring groups ranging in age from 12 years 5 months to 13 years four months based on reading level at a range of 11 years six months to 13 years six months. The individual groups contained eighteen to 24 students.

The groups were tested on a story "A New Horse." One group was given immediate recall following the time periods of 9:15 and 15:15. The remaining groups were tested the same day at the same times, but a week later. The study showed variance

on presentation time and delay of recall. Results of the study concluded immediate recall was prevalent in the morning versus recall in the afternoon testing. The strength of this study lies in the use of meaningful material, instead of random association of material. A time delay of 15 minutes did occur during the testing, which according to some may not be recognized as immediate delay depending upon the arousal effect (Folkard, 1979).

Folkard (1980) suggested that the presentation of immediate retention occurs in the morning, but only relative to retaining unimportant information, whereas afternoon presentation results in retention of both unimportant and important information. The study suggests maintenance processing is prevalent during arousal because the brain places no value on the degree of learned material. Further mentioned was the possibility this may interfere with more elaborative processing, thus reducing delayed retention. The correlation between the brain's use of material and state of arousal creates a continuum toward time of day of delivery and recall. Supportive of his previous finding, Folkard (1980) concluded morning retention focused on maintenance; whereas afternoon attention focused on elaborative processes relative to brain hemispheres. The possible relationship of arousal to physical fitness would create a positive correlation for improved academic performance (Taras & Potts-Datema, 2005).

Guthrie, Ash, and Bendapudi (1995) found a significant occurrence with morningness based on performance levels to support diurnal preferences and timing as a means of academic improvement. An attempt to raise academic performance would be a correlation between instruction timing and individual diurnal preferences (Kirby & Kirby, 2006). A study by Schmidt, Collette, Cajochen, and Peigneus (2007) ignites a new avenue of cognitive stauation based on sensitivity to testing material and optimal



diurnal performance timing. The accumulative effects of daily routines on cognitive performance and alertness reflect the possibility of improvement. Research suggests a steadfast relationship between neurophysiologic aspects and scheduling to achieve optimal academic performance. Individuals scheduled at appropriate diurnal times, respective to their unique learning period, will be more apt to excel in their academic endeavors.

Educators have all experienced the effects of sleep distributions on school-aged children in the form of absenteeism, tardiness, lack of attentiveness, moodiness, behavior problems, and poor academic performance (Wolfson & Carskadon, 1998; Wolfson & Carskadon, 2005; Wolfson et al., 2007). Adolescents from 10 to 17 years in age need approximately nine hours of sleep per night (Wolfson & Carskadon, 2005; Wolfson et al., 2007). The National Sleep Foundation suggests an even higher number of required sleep time (10 to 11 hours) for school age children ages 5 to 12. An overlap of ages 10 years to 12 years is evident in the two determinants of required sleep. Studies have shown that as children enter into adolescence, sleep-wake cycles are altered up to one hour more than second graders and 25 minutes more than fourth graders (Amschler & McKenzie, 2005; Sadeh, Raviv, & Gruber, 2000). These biological changes are evident in research but not in the educational system. School start times are still operating on the premise of older children to younger children with little to no flexibility for student performance. Little change of start times has been documented in a study by Wolfson and Carskadon (2005) over a fifteen -year span from 1986 - 2002. Evidence (Kubow et al., 1999) of improved learning and energy levels of elementary students with an hour delayed start times supports the need for educational leaders' consideration of the importance of the

psychological component of learning. Individuals who prefer the morning are more apt to be attentive and on task; whereas individuals who prefer the afternoon will experience a slow start (Randler & Frech, 2009).

### Circadian Rhythm and Physical Activity

These achievement levels influenced by circadian rhythm focused attention toward the timing of testing to influence subject area performance inclusive of physical performance. A study by Drust et al. (2005) relates physical performance to academic achievement. The intensity of exercise correlates to recall of instruction and complex thought associate with strategic decisions. This study lends support to the prospect of coming circadian rhythm with physical performance related to cognitive thought process, recall and function. Strategic planning of the day shows a relationship between specific subjects, and circadian rhythm. Davis (2001) drew a connection between learning patterns on the recall specific to reading. The study participants included 100 6-year-olds randomly selected from 39 first-grade central California school districts (Davis 2001). Instruction of reading was delivered in both morning and afternoon time periods. Participates were randomly assigned to learning cells: early/low-ability, early/high-ability, late/low-ability, late/high-ability. A positive relation was drawn toward the afternoon achievement in reading verses morning reading achievement. The study used a randomized selection of individuals from a large sampling area, but reduces to a low sampling number for the actual testing. The equalization of gender reduces any gender bias in the experiment. A limitation could be concluded from the interjection of nine participates into the study due to missing data. The experiment reinforces the attributes of time to day to the study. Contrary to Davis's finding, Muyskens and Ysseldyke (1998)

suggest there is not a correlate that exist between testing academic performance and academic achievement. The suggested findings report teacher input is the key to successful performance in the classroom. A study by Kirby and Kirby (2006) does see a correlation between academic growth as compared to morningness and eveningness. Drawing the correlation specific timing of the day is related specifically to the circadian rhythm of the individual, which increases the possibility of improved performance related to natural choice of selection of an individual's circadian rhythm.

A neurological and psychological relationship links circadian rhythm and physical activity. Circadian rhythm phases are interpreted during sleep disruptions (Reilly, 2009), but exercise can offset the effect of phases delays. Intensity of exercise acts as a zeitgeber to create patterns of phase shift (Edwards et al., 2009), which impacts the circadian pacemaker marked by body temperature changes (Yamanaka et al., 2006). The intensity levels of exercise raise the core body temperatures, which are evident by rectal temperatures during and after exercise (Miyazaki, Hashimoto, Masubuchi, Honma, & Honma, 2001). The correlation of phase shift due to exercise intensity and circadian phase shifting implies the impact of exercise on circadian rhythm. The impact of the relationship has the possibility not only to affect school scheduling, but also to recognize different student potential levels based on diurnal preference. Weaker students may benefit in class scheduling in the early morning due to a lower level of classroom accomplishment at this period (Klein, 2004). This lessens the achievement gap, creating an comparative environment for student to learn cooperatively.

## Physical Activity and Cognition

Education of the student of the 21<sup>st</sup> century requires an understanding of the thought processes of the new generation of student (Pienaar, 2009). The interjection of new experiences aroused by physical exercise will incite a generation of whole body learners. Movement enhances cognitive function, which is optimized through neural stimulation that uses these new experiences to maximize the full potential of the learner (Leppo, Davis, & Crim, 2000; Pienaar, 2009). This missed moment of engaging the whole body learner may impede ultimate cognitive potential. The mutuality of improved cognition performance and exercise develops a perceived concept of the importance of physical activity. Neurological and psychological changes both identify markers for academic improvement. The rise in core temperature produced by exercise stimulates changes in higher-order skills (Waterhouse et al., 2005). The increase of neurotransmitters associated with increased exercise produced higher grade- point averages (Field, Diego, & Sanders, 2001).

Academic performance levels of individuals involved in physical activity (Dwyer, Sallis, Blizzard, Lazarus, & Dean, 2001; Field et al., 2001; Sallis et al., 1999) increased due to arousal stimulation of exercise. This arousal stimulation of physical activity suggests that rates of academic learning per unit of class time improved based on activity level of the individual (Shephard, 1996). Exercise intensity levels play an important part in the elevation of cognition stimulation toward academic performance improvement, specifically executive function skills. Exercise intensity will not only impact cognitive performance in early stages of life, but also in the later years as well. Evidence supports executive functions processes, especially in the prefrontal cortex, show decrease

deterioration associated with aging (Hillman, Erickson, & Kramer, 2008). The engagement in high intensity levels of exercise that produce physiological arousal changes will impact improvement in executive functions throughout an individual's lifetime (Brisswalter, Collardeau, & Rene, 2002; Davis et al., 2007; Hillman et al., 2008).

### Vigorous Exercise, Oxygen, and Cognition

Oxygen acts as a catalyst in the respiration process to release energy from glucose molecules to produce energy. Exercise proportionally increases oxygen to the brain due to intensity levels of exercise. The speed of oxygen uptake ( $VO_2$ ) is proportionally related to the oxidative metabolism which is dependent on the efficiency of the body to create energy (Berger & Jones, 2007). At this plateau point oxygen transfer and usage are no longer transpiring. The individual has reached his or her  $VO_2$  max. The intensity level relative to fitness levels is linked equivalently with brain metabolism (Kemppainen et al., 2005).

The Trois-Rivieres study showed significance in peak oxygen uptake based on vigorous intensity interventions in the participants (Shephard & Trudeau, 2005). This signature study on physical exercise recognizes the relationship of exercise intensity, oxygen consumption, and academic performance. A study by Sohn, Chung, and Jang (2005) supports improved cognitive performance related to increased oxygen concentration that activated neural networks. The study included nine male right-handed students ranging in age from 21.9 years old to 26.9 years of age. Each participant did not have a history of psychiatric or neurological conditions. The participants were given increased oxygen of 21% and 30% at a constant rate of 8L/min. Inhalation occurred through homemade mask (Sohn et al., 2005). Cognitive performance was measured

using a verbal and visuospatial task derived from a Korean intelligence test, aptitude test, and general aptitude battery. Participants performed two runs, one at each level of oxygen, at which each performed four trails of four blocks of control and cognitive activity. Conclusive data concluded higher percentages of oxygen had a direct effect on the parietal lobe and frontal lobe. The SpO<sub>2</sub> increased from 97.5% to 98.1% which signifies oxygen was prepared and used for cognitive processes (Sohn et al., 2005).

Limitations to the study would be the number of participants in the study. The gains of this are the conclusive results relating to the use of oxygen through synthesized glucose. This study provides supportive evidence to the present study to the value of oxygen to improve cognitive function and the use of glucose toward neural stimulation of the brain for academic performance. A study by Moss, Scholey and Wesnes (1998) created possible results supporting the theory of increased oxygen content will enhance cognitive response. This study uses 20 healthy adults, 14 males and six females, 12 of which were smokers. Seven visits per participant were required on repetitive weekly times.

Participants were asked not to smoke (1 hour) or have caffeine (2 hours) before each testing session. Two parameter sessions were performed before actually testing began to ensure a baseline. The remaining five sessions consisted of baseline performance plus experimental session under the five protocols (Moss et al., 1997). The experimental session involved fluctuated oxygen content. Relative to this study the results revealed increased oxygen produced increased enhancements of word recall and picture recognition related to long-term memory. Components hindering the study included participants, including the physical health considering some individuals were smokers. The specific battery of cognitive testing components at sight covered adequately the

testing of areas in attention, long-term memory, and working memory, except for a discrepancy with the attentive test, which may not have provoked less cognitive effort. The conclusion in this study had supportive evidence to the idea of increased oxygen increasing cognition possibilities. In line with this thought, the transport of the needed oxygen plays a part in providing the fuel for cognitive processes to occur. Investigations into the increased cerebral blood flow (Herholz et al., 1987) provide supporting evidence of the need to increase brain metabolism through increased pumping of oxygen evident from results from resting to exercise state measured from released carbon dioxide. When brain metabolism increases, an increase in glucose occurs (Querido & Sheel, 2007). The increase in cerebral blood presents a causation of increased oxygen which presents more oxidation of glucose, thus increasing a positive response to cognitive performances.

The increase in intensity levels of physical exercise excites neurological and psychological sub-processes that promote cognitive improvements. Researchers have ascertained that vigorous intensity levels enable the individual to reach a threshold for improved academic performance (Berger & Jones, 2007; Coe et al., 2006; Hertzog et al., 2005; Stevens et al., 2008).

#### The Effects of Weight on Academic Performance

Physiological effects for learning can be adversely affected by overweight and obese composition, which shows a correlation to academic performance (Davis et. al, 2007; Taras & Potts-Datema, 2005) and behavioral performances (Judge & Jahns, 2007). The brain's plasticity allows life's experiences to alter their complexity, thus allowing for cognitive growth (Kolb, Gibb, & Robinson, 2003). Prospectively, educators can

influence overweight problems, which can positively affect educational outcomes (Judge & Jahns, 2007)

The National Health and Nutrition Examination Survey, using heights and weights, estimated that 17 % of children and adolescents between the ages of 2–19 are obese. The American Academy of Child and Adolescent Psychiatry estimations are even higher, estimating that 16 and 33 % of children and adolescents are obese. Obesity as defined by the Centers for Disease Control and Prevention, states a BMI at or above the 95th percentile for children of the same age and sex. Overweight individuals would be defined as having a BMI at or above the 85<sup>th</sup> percentile and lower than the 95th percentile. The decrease in physical activity and increase in poor dietary habits are only a few of the components leading to one of the most detrimental declines in health history. Schools can impact these issues by promoting physical activity (Rössner, 2002) and improved nutritional plans.

Moderate (Raj & Kumar, 2009) to vigorous exercise (Davis et al., 2007) can promote the reduction of weight, thus reducing the negative side effects of weight issues. In the study by Davis et al. (2007) executive function was specifically identified to improve under vigorous exercise conditionings. The relationship of executive function to academic improvement provides justification for the need to increase physical activity (Carlson et al., 2008) within the schools. The academic value of the school could be increased by improved health through physical activity by increased cognitive function and learning (Keely & Fox, 2009). The increased blood flow increases oxidative metabolism in the brain (Berger & Jones, 2007), but this oxidative process can be impeded by an overweight state (Newcomer, Larson-Meyer, Hunter, & Weinsier, 2001).



In a study by Clark, Slate, and Viglietti (2009), underweight and healthy weight students showed marked higher academic scores than overweight students, and obese students score even lower academically. Weight issues also affect circadian misalignments. Circadian disruptions and body weight are more prevalent in children and show signs of decrease with age (Gangwisch, 2009). Modern society has imposed zeitgebers, which cause phase shifts that impede the internal clock (Pérez-Chada, Drake, Pérez-Lloret, & Videla, 2009). These shifts cause disruptions in class performance based on optimal learning times and overweight issues of body adjustment.

#### Earmark Studies of Physical Activity

The role of physical education in academic performance is rooted in four studies designed to test the value of time spent in physical education and attributes. The quasi-experimental design in the Trois-Rivieres (Shephard & Trudeau, 2005) study encompassed a rural-urban continuum of 546 primary school students of appropriately equal gender in grades 1 through 6. Testing variations included a one-hour increase of vigorous physical education delivered by a specialist in physical education. Control groups, selected from immediately preceding and succeeding classes, received a minimal requirement of physical education by a non-specialist. The multi-year study assessed an un-weighted score of marks for parental language of French marks (four assessments covering the ability to listen, talk, read, and write, the ability to perform in mathematics, English (upper grades only), natural science, and overall conduct (the mean of five annual assessments) (Shephard 1996, 1997; Shephard & Trudeau, 2005). The first year of observation yielded an adverse correlation between the value of increased vigorous physical activity, but the advent of time of one year created an increase of performance in

grades 2 through 6. Significant gains were made in grades 2, 3, 5, and 6 and produced a gender variance toward girls.

Experimental impact of categorical comparisons yielded marks for French language instruction favored experimental classes in 13 comparisons and controlled classes in six instances, with no differences in 26 other comparisons. In mathematics, experimental classes obtained higher marks in four comparisons, equal marks in eight comparisons, and no poorer marks. In English language, experimental classes had higher marks in two comparisons, similar results for one comparison, and poorer marks in one comparison. Natural science instruction showed an advantage to experimental classes in four comparisons, equal performance in three comparisons, and poorer performance in one comparison. Deportment was unchanged by the experimental intervention, except in grade 6, where one of the two comparisons favored the experimental class (Shephard, 1996, 1997). This study provided evidence to support the value of physical education in schools. On a side note, the study added a component worthy of more study. Exercise in grades 3 through 5 showed increased oxygen intake, a component responsibility for increased cognitive function.

The increase in physical activity arousal stimulated cerebral blood flow allowing for increases in oxygen, triggering neurological releases to stimulate cognitive learning (Herholz et al., 1987; Querido & Sheel, 2007; Shepard & Trudeau 2005; Sohn et al., 2005; Swain et al., 2003). In the longitudinal study by Shephard and Trudeau (2005), an intake oxygen peak during exercise was determined. Exercise is known to increase the brain's metabolism (Querido & Sheel, 2007). Since aerobic exercise increases cell growth in the hippocampus, learning and memory area, a possible connection could be

drawn between avenues of cerebral blood flow and neuron connections (Herholz et al., 1987; Sibley & Etnier, 2003). The increased neuron connections may allow for more storage and processing of information. It would stand to reason that increased cerebral blood would increase the percentage uptake of oxygen removed from the blood for consumption toward performing cognitive tasks. The exertion of exercise increased the cerebral blood flow, which in turn increased the amount of glucose delivered from the hemoglobin. The increased oxygen content from the increased cerebral blood flow fuels the mitochondria. The mitochondria, the organelle responsible for ATP production, is stimulated to increase ATP production in the presence of increased oxygen from 32-34 ATP versus an increase of only 1-2 ATP in anaerobic conditions (Herholz et al., 1987; Sohn et al., 2005). The increased fuel supply for the brain may lead to improved cognitive function.

This study consisted of a large, gender diverse sampling group from differing cultural areas of rural and urban living. The extensive time span of the study allowed for physiological changes to occur in the participants toward cardiovascular and muscle function (Shephard & Trudeau, 2005). The intensity and duration of the study encompassed a well-documented, reliable study toward the benefits of physical education. Limitations of the study resulted from physiological changes related to puberty and possible apathy of participants toward testing. A questionable component was raised in a study by Coe et al. (2006) of the effect of habitual physical activity on the outcome of the Trois Rivieres (Shephard & Trudeau, 2005) study. In comparable representation the two studies reached opposite conclusions to the effect of habitual physical activity. In the Trois Rivieres (Shephard & Trudeau, 2005) study, the data

supported that time spent in physical education classes enhanced academic learning. In the Coe et al. (2006) study, habitual physical activity outside of school had more influence over academic learning than physical education classes.

The positive correlation between physical education and academic achievement derived from the study led to other studies measuring the effect physical activity had on academic performance. These studies showed a positive correlation toward physical education, as well, but did not present the aerobic aspect to provide details in the study. The slowest assimilation to the number of components to be measured was performed in the Vanves, France, and project in the suburbs of Paris. The design of the project included lengthening the day from 32 hours to 41.5. The lengthened hours provided two periodical times for napping. For the purpose of identification of time periods, these time periods would be considered afternoon in the United States. Academic class time spans were limited and performed only in the morning. The afternoon was devoted to physical activity. Comparisons were made with a nonrandomized control group from other area schools in the Paris. The results concluded on the certificate of study a comparable performance with the control group which included the 26 % increased instruction. The proposed results showed a representative relaxed, attentive group in the experimental group with fewer behavioral issues than the control group. The study concluded a positive correlation for increased physical education time as related to academic performance. Apparent limitations were small representative sizes and the alternation of the day to fix the project (Shephard, 1997). The benefits of the actual study would have provided possible insight into support for the original study. The use of the secondary source did not allow for the exploration into the variables used in the study. This was the

only study combining the three components; even though not in the same manner as this study, it would have been valuable to review. The SPARK study (1999), conducted in an affluent neighborhood in Southern California, proposed a design curriculum of physical activity over a 2-year span by trained and untrained professionals to find a correlation between physical activity and its detriment to academic performance. The study concluded that time spent in physical education classes does not hinder academic performance. The positive aspects of the study included randomization, trained and untrained personnel, and standardized testing. The sampling group was comprised of one socioeconomic group. This study supports the conclusion that increased physical activity increases academic performance (Sallis et al., 1999; Sibley & Etnier 2003). The last foundation study is the Australian Study (SHAPE) (1996). This study was conducted on 9,000 school children between ages 7 and 15, subdivided into equal groups of 500 in each sex/age. The study involved two stages of sampling. The second stage of sampling included randomly selected 10 boys and 10 girls in each age group in the selected schools. Of the 9,000 students, 2,400 children were randomly selected to undergo measurements of blood pressure, body fatness, endurance fitness, and blood lipid analysis (Dwyer, Blizzard, & Dean, 1996). No significant difference was detected in academic performance in this study, but a point toward the present study of an increase in endurance fitness was detected. Limitations to this study included the time span. The study did bring forth evidence to support that forms of physical activity could be enhanced without a determinable effect to academic performance (Dwyer et al., 1996; Shephard, 1987; Sibley & Etnier, 2003).

### Executive Function/Circadian Rhythm/Physical Exercise Justifications

An individual's involvement in physical activity will promote vigorous mental health (Hertzog et al., 2009). Improvements in mental health show a specific increase in higher-order thinking skills (Etnier & Chang, 2009; Hertzog et al., 2009). The indices of physical exercise and circadian rhythm demonstrate an avenue for continued means of improving academic skills, specifically executive function, in schools. A solid program of physical activity in schools has the possibility of not only increasing academic performance, but also improving attention and discipline problems. Knowledge brings awareness that will enable school administrators to make researched-based decisions to improve the overall performance of the student related to the components of scheduling and diurnal preferences. The knowledge of diurnal preferences could cause an interest in the alignment of school times based on evidence from a study by Carskadon, Vieira, and Acebo (1993), which recognizes the possibility that start times run counterclockwise to individual normality of wake times related to age. This will ensure that time spent in classes will maximize potential for learning (Shephard, 1997). This educational knowledge will enable government, schools, and communities to make strategic decisions concerning educational funding and operation performance.

Financial funding and political constraints are two overwhelming limiting factors that educational leaders face in constructive decision-making rooted in the indices of No Child Left Behind toward improved student growth (Geierstanger et al., 2004). Educational leaders have to convince and invest stakeholders in the importance of new avenues of educational enrichment to embody the whole learner while not falling into a trap of "gaming" the system. Evidence of conscious or unconscious "gaming" of the

system is evident in student reclassifications, class scope reductions, cheating, retaining students, and nutritional loading on test days (Figlio & Winicki, 2002; Rouse et al., 2007). Research by Rothstein and Jacobsen (2006) of biased testing on reading and math scores, specific to standards provided by No Child Left Behind, is actually broadening the achievement gap in minority areas.

Physiological advantages associated with physical exercise (Bladyes, 2001; Coe et al., 2006; Jensen, 2005; Shephard & Trudeau, 2005; Sohn et al., 2005; Stevens et al., 2008) offer other avenues of increasing student potential. Congressional funding, such as the Carol M. White Physical Education Act under Title X of the Elementary and Secondary Act, relieves some of the financial constraints of pursuing this new avenue. Physiological and biological advantages can be extended further through adjusted and flexible scheduling of school start times and curriculum, which consider time of day and diurnal preference in improving student learning (Folkard, 1979; Hines, 2004; Klein, 2004; Kubow, Wailstrom & Bemis, 1999). Delayed start times and preferential scheduling can impact absenteeism, dropouts, and academic performance (Wolfson & Carskadon, 2005; Wolfson et al., 2007). Research by Wolfson and Carskadon (2005) offers educational leaders a systematic approach to engage stakeholders in the value of delayed start times and flexible scheduling, such as stakeholder assessments, school scheduling options, homework controls, activity and athletic scheduling, and evaluations of sleep patterns associated with student absenteeism and attention deficit. In respect to No Child Left Behind, educational leaders can see the value of exploration into this avenue, which considers the physiological and biological components of the learner.

## Summary

This chapter provided supported literature on the biological effects of circadian rhythm with and without exercise influences on academic achievement, specific to this study executive function. The theoretical base for the intertwining physiological and psychological components is rooted in brain-based learning. The aspect of whole body learning is examined by the literature on the topics of circadian rhythm, executive function, and physical activity and then provides a cumulative view of each component with another of the components.

Individuals follow a biological process, circadian rhythm, that engages mental and behavioral changes that are relative to light and dark cycles (National Institute of General Medical Sciences, 2008). The misalignment of these cycles created by wake times is not specific to individual diurnal cycles (Duffy et al., 2001) will impair the cognitive functions of the individual. Morningness/Eveningness acts as an identifier for diurnal preferences, larks and owls (Randler & Frech, 2009). The implication for schools for students' overall achievement lies in the balance.

Body temperature affects the circadian rhythm phasing cycle (Waterhouse et al., 2005) that in turn can be impacted by intensity levels of exercise. Oxygen release is stimulated to maintain equilibrium, thus enhancing the brain's fuel supply. The increased oxidation promotes neurological messaging for increased brain activity (American College of Sports Medicine, 2003; Berger & Jones, 2007; Herholz et al., 1987; Moss et al., 1998; Pienaar, 2009; Querido & Sheel, 2007; Shephard & Trudeau, 2005; Sibley & Etnier, 2003; Sohn et al., 2005; Swain et al., 2003). Intensity levels of exercise produce changes in circadian rhythm and the cognitive process of executive function. This



neuophysiological state facilitates the cognitive processes associated with higher-order thinking skills (Davranche & Audiffren, 2004; Tomporowski, 2003).

The psychological component of obesity hinders academic performance (Clark et al., 2009) as well as affects the circadian rhythm alignment. These discrepancies are more evident in children (Gangwisch, 2009). Increased intensity levels of exercise can help balance the obesity issues and circadian phasing. Indices of academic performance, attention, and disciplinary problems are relevant to increases in vigorous physical activity and scheduling based on diurnal preferences. Financial constraints and political opposition confine educational leaders in the pursuit of new avenues to improve student learning. Research by Wolfson and Carskadon (2005) provides supportive evidence of the value of proper scheduling with diurnal preferences as a systematic means to improve education.

## CHAPTER III

### METHODOLOGY

#### Overview

This causal comparative study was designed to examine the effect that circadian rhythm has on executive function under conditions of vigorous exercise. The proposed purpose of this study was to determine if diurnal preference affects students' executive function abilities when dosed with conditions of vigorous exercise. The study used a Morningness/Eveningness Questionnaire (Carskadon et al., 1993) to determine diurnal preference (Appendix A). A pretest and posttest was given using the Wisconsin Card Sorting Test 64 to determine the impact vigorous exercise imposed on the results during diurnal and non-diurnal preference times.

#### Research Design

This causal comparative study sought to explore the effect of circadian rhythm on executive function when exposed to conditions of vigorous exercise. The independent variables in the study are testing time of day and diurnal preferences of morningness or eveningness. The dependent variable in this study is the change in pretest and posttest results on the Wisconsin Card Sorting 64 test (Cianchetti et al., 2007; Feldstein et al., 1999; Lemmink, Visscher, Lambert, & Lamberts, 2004; Vayalakkara et al., 2000) after exposure to vigorous exercise in diurnal and non-diurnal times of preference. The initial determinant for this research project is the diurnal preference of the participant, which was measured using the Morningness/Eveningness Scale for Children Questionnaire (Caci, Robert, Dossios, & Boyer, 2005; Carskadon et al., 1993; Francisco, Diaz-Morales, Davila de Leon, & Sorroche, 2007) on day 1 of the project described in Step 1 below. On

day 2 of the project, a baseline of executive function was obtained using the Wisconsin Card Sorting Test 64 as a covariate described in Step 2 below. The next stage of the research project was conducted on the third day (Step 3) to allow time to determine the diurnal preferences and establish a baseline of the Wisconsin Card Sorting Test 64 data. The participants on the third day were exposed to vigorous exercise using the Multi-Level 20 Meter Shuttle Run. The Multi-level 20 Meter Shuttle Run is a valid and reliable measure of estimated VO<sub>2</sub> maximum (Aziz et al., (2004); Ortega et al., 2008; Paliczka et al., 1987). The estimated VO<sub>2</sub> maximum was converted to intensity levels using David Swain's exercise intensity formula to ensure vigorous exercise conditions. A selected sample (Activity 2:a) chosen within the initial research group had an oximeter applied to their fingers at the end of the Multi-Level 20 Meter Shuttle Run to support oxygen saturation from the vigorous exercise conditions. The second stage of testing (Activity 2:b) on Day 3 for all participants was to re-administer the Wisconsin Card Sorting Test 64 within 10-15 minutes of completion of the vigorous intensity exercise. The time period of 10-15 minutes is an estimation of time before the participant returns to his or her resting heart rate.

The data were collected to make determinations about the effect of circadian rhythm on executive function when exposed to conditions of vigorous exercise. The following questions provide a foundation for the items addressed in this research design:

1. Is executive function affected by testing time alone when exposed to vigorous intensity levels of exercise?
2. Is executive function affected by individual diurnal preferences (morninness-eveningness) when exposed to vigorous intensity levels of exercise?

3. Is executive function affected by the interaction of testing time and morningness-eveningness when exposed to vigorous intensity levels of exercise?

#### Participants

The participants for this study were male and female students in the sixth grade ranging in ages from 11-14 from two southern parishes in Louisiana. A comparative sample of students were comprised of approximately 100 students of various condition levels, ethnicity, gender, and socioeconomic backgrounds from local elementary schools within the two southern parishes of Louisiana. The participant population participated in a 3-day process to determine the effect of circadian rhythm on executive function under vigorous exercise conditions.

#### Instrumentation

Step 1: The initial process of the procedure began with a self-descriptive Morningness-eveningness Scale for Children questionnaire that took take approximately 15 minutes for the participants to complete on day 1 of the study. The questionnaire included 10 questions that determine maximal or minimal morningness based on response answers to questions relating to recess, tests, bedtime, and rising time (Carsakadon et al., 1993). The scores are derived by adding points for each answer: a =1. b = 2, c = 3, d = 4, e = 5, except as indicated by \*, where the point values are reversed. The maximum score is 42 (maximal morning preference) and the minimum is 10 (minimal morning preference) (Carsakadon et al., 1993).

Step 2: On day 2 of the study, once morningness/ eveningness has been established, the students will take the Wisconsin Card Sorting Test 64. The original version of the Wisconsin Card Sorting Test was written by David A. Grant and Esta A.

Berg and was designed to use paper cards from the experimenter. This study used a computerized version of the Wisconsin Card Sorting Test 64 (WCST 64) which automatically scores the test, thus eliminating scoring errors and shortening test time. The approximate time to administer the computerized version of the Wisconsin Card Sorting Test-64 is 12 to 20 minutes.

Step 3: The next phase of testing was on the third day from the initial phase of testing. On the third day of testing, the participants were administered the Multi-Level 20 Meter Shuttle Run (Leger, Mercier, Gadoury & Lambert, 1988) to estimate  $VO_{2\max}$ . The Multi-Level 20 Meter Shuttle Run is a series of shuttle runs between two designated points 20 meters apart that dictate a running pace for the participant through a series of auditory signals (Pilianidis et al., 2007). Each beep represents a level. If a participant reaches the line before the beep sounds, then the participant must remain on the line until the beep sounds. If the line is not reached at the point the next beep sounds, participants have two beep cycles to catch up or the test ends and  $VO_{2\max}$  is recorded. This estimation of  $VO_{2\max}$  will be converted to an intensity level using a formula Swain's exercise intensity formula. The exercise intensity formula mathematically estimates the participant's exercise intensity as a percentage of  $VO_{2\max}$ . A smaller sample of participants within the initial research group had oxygen saturation checked using an oximeter. The final component of testing, Wisconsin Card Sorting Test-64, was administered as a post-test within 10-15 minutes of completion of the Multi-Level 20 Meter Shuttle Run before resting heart rate is achieved.

## Procedures

Upon required IRB permission (Appendix B) and request of principal approval (Appendix C), the researcher spoke to all physical education instructors at their convenience informing them of their role in the study. At this meeting the physical education instructors were given written instructions for their role in the process (Appendix D). The instructions included the designated days approved by the principal for the testing to occur, a short synopsis of the events, parent and student permission letters, ethic responsibilities, and envelopes. The physical education instructors were given an opportunity to ask questions of the researcher in order to clarify any uncertainty. During physical education class, each physical education instructor distributed parental permission slips (Appendix E) from a designated envelope provided by the researcher to elementary students in grades 6 in St. James Parish and Ascension Parish.

A meeting at each school with participants' parents was scheduled to answer any questions if any individuals are skeptical of the study. The physical education instructors were told to allow students two weeks to return the signed parental permission forms with determined extensions for time, if necessary. The physical education instructors made a list of participants who were allowed to participate in the study. At the end of the two-week period or extension, the parental permission slip envelope, along with the participant list, were sealed and locked in each physical education instructor's office. The following week after the return of the parental consent letters the physical education instructors distributed student assent letters (Appendix F) provided by the researcher to those students with signed parental permission forms from the parental consent participant lists. The assent letters signed by willing participants, along with the parental

consent participant lists, were returned to a separate designated envelope and sealed. These envelopes were kept with the parental permission letters in the locked physical education instructors' offices.

Day 1: On Day 1 of the research project the physical education instructors designated an area for participants to sit to complete the questionnaire. The physical education instructors gave these students the questionnaires (Appendix G). The physical education instructors informed the participants not to put their names on the questionnaires and reminded the participants that participation is voluntary. The participants returned the completed questionnaires to their physical education instructor once they completed the questionnaires. The students were given questionnaires color-coded for the schools with identifying animal labels to allow for identification. The participants then return to another designated area for individuals who completed the questionnaires. The physical education instructors collected all questionnaires, placed them in designated envelopes, and sealed them. The list of participants' names and animal identifiers were placed in designated envelopes and sealed. The four envelopes were kept locked in the physical education instructors' offices. The researcher personally collected the four envelopes from the physical education instructors from each school at the end of the first research day. The envelopes containing the questionnaires were opened and the data compiled to determine morningness/eveningness. The remaining three envelopes remained sealed unless participants forget identifiers on the second day of the research project. In this case, the participant identifier envelope was opened allowing the student to recall his or her animal identifier. The researcher obtained the envelopes from the physical education educators' offices for analysis and storage. These

envelopes were only reopened if the researcher needs information to complete the research projects. The data were kept in a locked filing cabinet in the researcher's office until the information is no longer pertinent for study. At this point, the information will be shredded.

Day 2: The researcher analyzed the questionnaires for results to calculate the diurnal preferences of the precipitants using the Morningness/Eveningness Scale for Children scoring system. The second phase of testing on Day 2 was the administering of the computerized version of the Wisconsin Card Sorting Test 64. Students from the tested physical education classes were divided into a.m. and p.m. groups according to diurnal preference and lack of preference for testing using the WCST 64. This required approximately 12-20 minutes to complete. The student used the same animal identifier and color-code for the school to allow for identification analysis of pretest and posttest on the Wisconsin Card Sorting Test 64. The results of the WCST 64 were scored by the computer on variables associated with executive function for this study. These scores were used later to determine the change between pretest posttest results on the WCST 64. The students, on completion of the test, were escorted back to physical education class by volunteers. After being used by the researcher to compile results, the data were stored and the WCST 64 software was removed by the research and placed in researcher's office in locked filing cabinet.

Day 3: The third day of testing involved the execution of the Multi-level 20 Meter Shuttle Run to create conditions of vigorous exercise. This portion of the research was monitored by two registered nurses to ensure the safety of the individuals during this physical activity portion of the project. Any individuals experiencing



difficulty were immediately removed by the nurses from the research project and their results were excluded from the study.

Activity 1: Participants ran side to side between two cones 20 meters apart. These runs are synchronized with laptop software which plays beeps at set intervals that shorten to increase the speed of the participant. The participant continues until he or she cannot keep in sync with the beeps. The participant has reached his or her maximum  $VO_2$  level.

Activity 2a: At this time pre-selected participants had a noninvasive oximeter placed on their fingers for less than a minute to determine oxygen saturation by the student nurse volunteers and then escorted to the computer lab for re-administering of the WCST 64.

Activity 2b: The other participants who selected for the oximeter test were removed immediately at the completion of the course by a student nurse volunteer and escorted to the computer lab for the re-administering of the WCST 64. The WCST 64 was re-administered within 10 to 15 minutes after the completion of the Multi-Level 20 Meter Shuttle Run. The student nurse volunteer remained with the participants to ensure that no resilient effects occur from the exercise. The students used the same school color code and animal identifier as the first day the students took the WCST 64 for recognition for analysis of pretest and posttest results. On completion of the WCST 64, students were escorted by the student nurse volunteers back to their physical education class. Students were given PowerAde to relinquish any electrolytes missing due to the exercise process. The data was stored and the software removed from the computers. All

information obtained was stored in the researcher's office in a locked filing cabinet until no longer pertinent for study.

### Limitations

Internal validity for this research study was impacted by bedtimes. Because bedtimes are more stable in childhood than in the adolescent ages, unstable circadian phase markers could have imposed inconsistencies with performance on the WCST 64 related to diurnal preference. The facility's floor surface could also have impacted the results if the participants slipped, which would interrupt their ability to synchronize with the beeps. The temperature conditions of the exercise facility could possibly raise body temperature creating premature fatigue. Psychological disorders that interfere with the student's ability to sleep or his or her cognitive ability could possibly have impacted the results of the study. The individual's computer skills may impact his or her the speed of cognitive change on the WCST-64; but in this age group, this was likely not considered a large determinant. Estimations of vigorous intensity levels were calculated using researched-based instruments, but these were estimations. Students' maximal participation in completion of any of the tests could only be assumed.

### Data Analysis

A two-way ANOVA with a repeated measure on the Wisconsin Card Sorting Test-64 were be used to analyze the three research questions in this study.

Step 1: The morningness/eveningness scale for children (MES-C) derives a score from 10 questions to determine maximal and minimal morning preferences. The scores are derived by adding points for each answer: a =1, b = 2, c = 3, d = 4, e = 5, except as indicated by \*, where the point values are reversed. The maximum score is 42 (maximal

morning preference) and the minimum is 10 (minimal morning preference (Carsakadon et al., 1993) (Appendix H). This scale was used to group participants into Group A morning types and Group B non-morning types for testing in the a.m. on the Wisconsin Card Sorting Test 64 (WCST 64). The scale was also used to group participants into Group C morning types and Group D non-morning types to be tested in the p.m. on the WCST 64.

Step 2: The Wisconsin Card Sorting Test is a widely used test for executive function because of the test reliability scores ranging from .60 to .85. On the second day of this research project, a pretest was administered using the grouping above to set a baseline for executive function based on testing during diurnal preference or non-diurnal preference times.

Step 3: On the third day, a post test was administered using the same grouping above to determine a change after vigorous exercise conditions had been imposed to address if time of day and/or morningness and eveningness influence results on the WCST 64 on executive function components. A repeated measure analysis was run to determine the differences in scores on the WCST before and after exercise.

Vigorous exercise conditions were imposed on the third day using the Multi-stage 20 meter shuttle run (Aziz, Yau, & Kong, 2004; Flouris, Metsios, & Koutedakis, 2006; Lemmink et al., 2004; Paliczka et al., 1987; Ramsbottom, Brewer, & Williams, 1988;) after which the WCST was readministered. The multi-Level 20 Meter Shuttle Run uses a series of beeps at intervals of increasing speed to estimate  $VO_{2\text{ max}}$ . These calculations were made by Multi-Level 20 Meter Shuttle Run software to determine  $VO_2\text{ max}$  based on the number of levels and shuttle runs completed. This estimation was converted into

intensity levels using the Swain Intensity Level Formula ( $\%MHR = 0.64 \times VO2 \text{ Max} + 37$ ) to ensure that vigorous conditions exist.

### Summary

Chapter III provides the methodological procedure used to determine the effect of circadian rhythm on executive function when exposed to vigorous exercise conditions. The participants were chosen from the sixth grade in two Southern Louisiana Parishes, ranging in age from 11 to 14. The instruments used to determine the relationship are the Morningness/Eveningness Scale for Children (Carskadon et al., 1993) and the Wisconsin Card Sorting Test 64 (Cianchetti et al., 2007; Feldstein et al., 1999; Lemmink et al., 2004; Vayalakkara et al., 2000). Vigorous exercise conditions were created using the Multi-Level 20 Meter Shuttle Run (Aziz et al., 2005; Lemmink et al., 2004; Ortega et al., 2008; Paliczka et al., 1987). The analyses used for result discover was a two-way ANOVA with repeated measures on the Wisconsin Card Sorting Test-64.

## CHAPTER IV

### RESULTS

#### Introduction

This chapter addresses the research sample and questions, and the collection and analysis of data. This causal comparative study examines the relationship of time of day and diurnal preference (independent variable) on executive function (dependent variable) under vigorous exercise conditions. Diurnal preferences (main effect) were clarified using the Morningness/Eveningness Scale for Children Questionnaire. A pre-test and post-test of the computerized version of the Wisconsin Card Sorting Test 64 (interaction) was used to identify changes in executive function when stimulated by vigorous exercise conditions. The stimulated vigorous exercise condition was achieved using the Multi-Level 20 Meter Shuttle Run, which was converted to intensity using Swain's exercise intensity formula. Brain-based learning provided the theoretical framework to explore the physiological and psychological interrelationship toward increasing academic achievement. A two-way analysis of variance (ANOVA) with a repeated measure on the Wisconsin Card Sorting Test-64 was used to analyze the main effects and interaction between time of day and diurnal preference.

#### Sample Description

The population of this study included 100 sixth grade participants, ranging in ages from 11-14 years, from two southern parishes in Louisiana. Gender identification for this study included 40 males and 60 females with an ethnic composition of 65% African American and 35% Caucasian participants. Frequency age distribution identified the

participants as twenty-six 11-year-olds, sixty-one 12-year-olds, ten 13-year-olds, and three 14-year-olds.

### Statistical Procedure

This causal comparative study explored time of day and diurnal nondiurnal preferences effect on executive function when exposed to vigorous activity conditions. The independent variable time of day was determined using the Morningness/Eveningness Scale for Children (MESC) questionnaire (Carskadon et al., 1993). The Morningness/Eveningness Scale for Children determined the participant's preference for morning and evening, based on scale range from 10 to 42; 10 being the extreme for eveningness and 42 being the extreme for morningness. The mean of 26.59 was determined from the cumulative MESC questionnaires as the division line between diurnal preferences with scores of 26 included in the afternoon group. According to morning and afternoon preference, a pretest of the Wisconsin Card Sorting Test (WCST) was administered to participants during diurnal preferences (n = 50); whereas others were administered during non-diurnal preferences (n = 50). A posttest of the Wisconsin Card Sorting Test was administered on day 3 of the testing procedures following vigorous activity conditions, which were achieved using the multi-Level 20 Meter Shuttle Run. The scores were converted to intensity levels using David Swain's intensity formula,  $\%MHR = 0.64 \times \%VO_2 \text{ Max} + 37$ .

### Statistical Analysis/Findings

The statistical data were analyzed using a two-way ANOVA with repeated measures on the post-test Wisconsin Card Sorting Test. In this analysis, between-subjects groups consisted of diurnal preference and time of day, valued labeled 1=

morning (n= 36), 2 = afternoon (n = 54), and 1 = am (n= 70), 2 = pm (n= 30), respectively. The condition of time is identified as the within-subject factors, dependent variable repeated (WCST pre-test, WCST post-test).

Table 1 displays the descriptive statistics for diurnal preference and time of day on the pre-test and post-test of the Wisconsin Card Sorting Test. Morning diurnal preference participants in preferred time scored higher (M = 43.33, SD = 9.33) than morning diurnal preference participants in non-preferred time (M = 42.52, SD = 9.24) on the Wisconsin Card Sorting Test-64 pre-test. Afternoon diurnal preference participants in non-preferred time scored higher (M = 47.84; SD = 7.21) than afternoon participants in preferred time (M = 46.37, SD = 7.47) on the Wisconsin Card Sorting Test-64 pre-test. Posttest results on the Wisconsin Card Sorting Test showed a slight increase over pre-test results possibly due to practice effect. Morning diurnal preference participants in preferred time scored relatively the same (M = 47.45; SD = 8.20) as morning diurnal preference participants in non-preferred time (M = 47.31, SD = 8.88) on the Wisconsin Card Sorting Test-64 posttest. Afternoon diurnal preference participants in non-preferred time scored relatively the same (M = 48.59, SD = 7.12) than afternoon participants in preferred time (M = 49.41, SD = 9.53) on the Wisconsin Card Sorting Test-64 posttest.

The Wisconsin Card Sorting Test-64 bases the standardized scores on a mean of 100 with a standard deviation of 15. Based on normative data provided by the Wisconsin Card Sorting Test-64 students in this research project ranked in the 50<sup>th</sup> percentile to the 58<sup>th</sup> percentile on the pretest of the Wisconsin Card Sorting Test-64. On the post-test the students improved their rank to the 77<sup>th</sup> percentile to the 86<sup>th</sup> percentile. This is accumulative across norm tables for ages 11-14.

Table 1:

*Descriptive of WCST-64 Pre-test and Post-test*

	Diurnal Preference	Time of day	Mean	Std. Deviation	n
WCST1	morning	am	43.33	9.23	33
		pm	40.46	9.30	13
		Total	42.52	9.24	46
	afternoon	am	47.84	7.21	37
		pm	43.18	7.20	17
		Total	46.37	7.47	54
	Total	am	45.71	8.47	70
		pm	42.00	8.14	30
		Total	44.60	8.51	100
WCST2	morning	am	47.45	8.20	33
		pm	47.31	8.88	13
		Total	47.41	8.30	46
	afternoon	am	48.59	7.12	37
		pm	49.41	9.53	17
		Total	48.85	7.87	54
	Total	am	48.05	7.61	70
		pm	48.50	9.16	30
		Total	48.19	8.06	100

*Research Question 1*

An analysis of variance was conducted on the effect of time of day alone when exposed to vigorous intensity levels of exercise. The analysis resulted in non-significant main effect of time of day on executive function,  $F(1, 96) = 1.186, p = .279$ , (Table 2). Participants who were tested relative to time of day both in the morning ( $M = 43.33$ ) and afternoon ( $M = 43.18$ ) scored relatively the same on the pretest with a slight increase on the posttest of the participants' time of day testing, morning ( $M = 47.45$ ) and afternoon ( $M = 49.41$ ) (Table 2).



Table 2

*Tests of Between-Subjects Effects of Time of Day and Diurnal Preference*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	349895.79	1	349895.79	3401.34	.000
Diurnal Preference	283.53	1	283.53	2.76	.100
Time of day	121.97	1	121.97	1.19	.279
Diurnal Preference *	1.77	1	1.77	.02	.896
Time of day					
Error	9875.51	96	102.87		

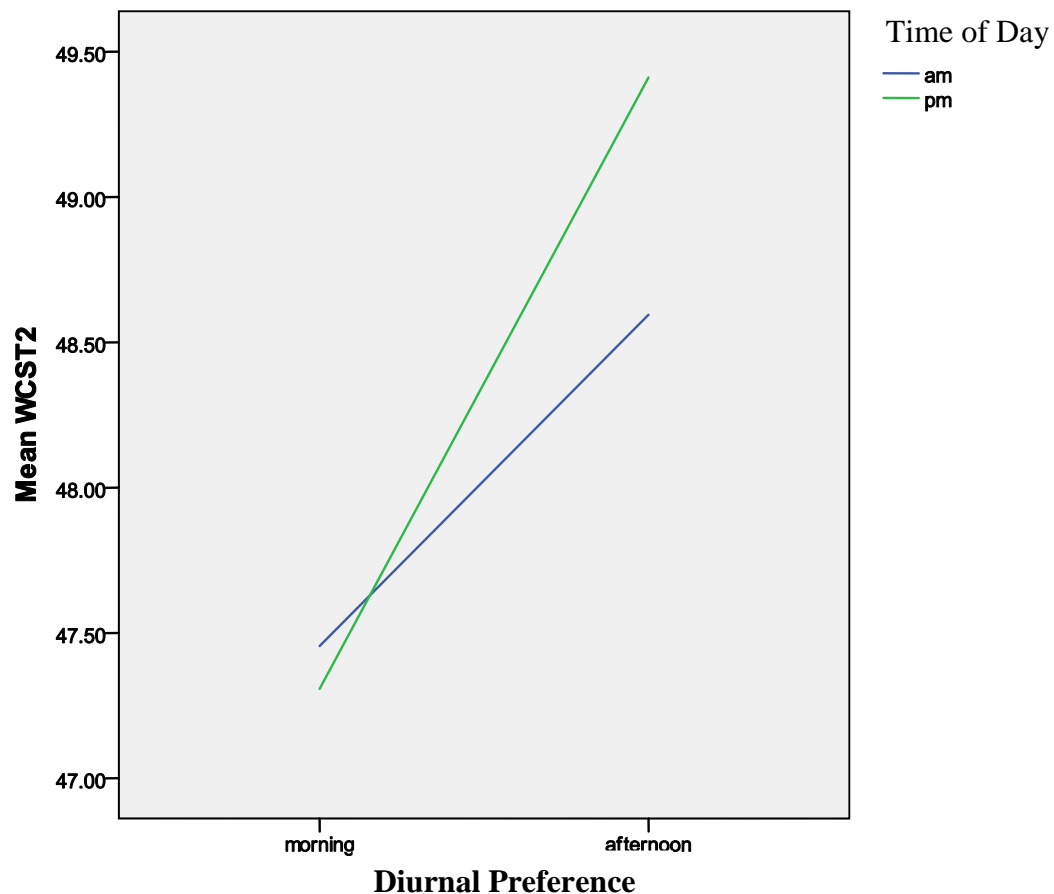
*Research Question 2*

An analysis of variance was conducted on individual diurnal preferences (morningness/eveningness) when exposed to vigorous intensity levels of exercise. This analysis revealed a non-significant main effect as well,  $F(1, 96) = 2.756, p = .100$ , (Table 2). Participants performed slightly higher in their preferred time ( $M = 43.33, SD = 9.23$ ;  $M = 47.45, SD = 8.20$ ;  $M = 49.41, SD = 9.53$ ) except on the pretest afternoon ( $M = 43.17, SD = 7.20$ ) (Table 1).

*Research Question 3*

Participants were tested based on diurnal preference and time of day to determine if a significant relationship on executive function after vigorous exercise was evident. Between-subject group analysis of diurnal preference ( $p = .100$ ) and time of day (.279) yielded no significance for these main effects. No statistical interaction was evident between diurnal preference and time of day,  $F(1, 96) = .017, p = .896$  (Table 2) on executive function when exposed to vigorous exercise. The results of this study do not support an interaction of testing time and diurnal effect on executive function after vigorous exercise. Figure 1 does show a slight interaction, but the morning diurnal

preferred (M = 47.45) and non-preferred (M = 47.30) testing group have relatively the same mean, which shows little differences between testing at preferred or not preferred times in the morning. This small interaction could possibly be explained by inadequate sample size.



*Figure 1.* Interaction of WCST-64. This figure illustrates interaction on WCST-64 between time of day and diurnal preference.

Vigorous exercise conditions were simulated in this study using the number of levels and shuttles completed by each participant to compute  $VO_2$  max. The  $VO_2$  max. obtained from the multi-stage 20 meter shuttle run is transferred into intensity using David Swain's intensity formula  $\%MHR = .064 \times \%VO_2 \text{ max} = 37$ . A subgroup of participants ( $n = 37$ ) was randomly selected for oximeter test of oxygen saturation to

ensure oxygen enrichment due to vigorous exercise conditions. All participants, except two, fell within the acceptable levels of 95% to 100% saturation. This supports participants reaching acceptable intensity levels of exercise and oxygen enrichment.

## CHAPTER V

### SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

#### Purpose

Education is faced with an overwhelming need for new indices to tap the minds of today's youth. Provisions of No Child Left Behind place an unbalanced weight of significance on standard scores in core areas of English/Language Arts, reading, and mathematics, which restrict the vision of educational leaders based on financial and political constraints, instead of student improvement. Evidence is needed to inform lawmakers and leaders in state and federal education to broaden the scope of vision for improving the 21<sup>st</sup> century learner. If a healthy body promotes a healthy mind (Hertzog et al., 2009), then educational leaders cannot ignore the significance of a physiological and psychological connection. The goal of this study was to add evidence of this connection by extending the literature on the effect that diurnal preference testing will have on executive function under vigorous exercise conditions.

This is a causal comparative study designed to focus on the effect of individual diurnal preferences on executive function when exposed to vigorous exercise conditions. This study examined the relationship of circadian rhythm on executive function under vigorous exercise conditions of sixth graders in two southern parishes in Louisiana in the spring semester, 2011. Diurnal preference was measured by Morningness/Eveningness Questionnaire for Children (Carskadon et al., 1993) and the Wisconsin Card Sorting Test 64 (Cianchetti et al., 2007; Feldstein et al., 1999; Lemmink et al., 2004; Vayalakkara et al., 2000) was used as the indicator of executive function. Vigorous exercise conditions were achieved using the Multi-Level 20 Meter Shuttle Run (Aziz et al., 2005; Lemmink

et al., 2004; Ortega et al., 2008; Paliczka et al., 1987) and converted to intensity level using the David Swain intensity exercise formula. A selected sample from the initial research group was evaluated using an oximeter to support oxygen saturation from the vigorous level of exercise. The results of this research will extend the literature on the effect of individual diurnal preferences on executive function when exposed to vigorous exercise conditions.

### Participants

For the purpose of this study, the participants consisted of 40 males and 60 females ranging in ages from 11-14 years from the sixth grade in two southern parishes in Louisiana. The sample size of 100 students included 65% African Americans and 35% Caucasians participants. Student participation was voluntary upon receiving parental permission.

### Methods

Step 1: The initial process of the procedure upon receiving permission was a self-descriptive Morningness/Eveningness Scale for Children questionnaire that took approximately 15 minutes for the participants to complete on Day 1 of the study. The questionnaire included 10 questions that determine maximal or minimal morningness based on response answers to questions relating to recess, tests, bedtime, and rising time (Carsakadon et al., 1993). The scores were derived by adding points for each answer: a = 1, b = 2, c = 3, d = 4, e = 5, except as indicated by \*, where the point values were reversed. The maximum score was 42 (maximal morning preference) and the minimum was 10 (minimal evening preference) (Carsakadon et al., 1993).

Step 2: On Day 2 of the study, once morningness/eveningness had been established, the students took the Wisconsin Card Sorting Test 64 as a pre-test for executive function. A computerized version of the Wisconsin Card Sorting Test 64 (WCST 64) was administered and automatically scored, thus eliminating scoring errors and shortening test time. The approximate time to administer the computerized version of the Wisconsin Card Sorting Test was 12-20 minutes.

Step 3: The next phase of testing was on the third day from the initial phase of testing. On the third day of testing, the participants were administered the Multi-Level 20 meter Shuttle Run (Leger et al., 1988) to estimate  $VO_{2\max}$ . The Multi-Level 20 Meter Shuttle Run is a series of shuttle runs between two designated points 20 meters apart that dictate a running pace for the participant through a series of auditory signals (Pilianidis, et al, 2007). Each beep represents a level. If a participant reaches the line before the beep sounds, then the participant must remain on the line until the beep sounds. If the line is not reached at the point the next beep sounds, participants have two beep cycles to catch up or the test ends and  $VO_{2\max}$  is recorded. This estimation of  $VO_{2\max}$  was converted to an intensity level using Swain's exercise intensity formula. The exercise intensity formula mathematically estimates the participant's exercise intensity as a percentage of  $VO_{2\max}$ . A smaller sample of participants within the initial research group had oxygen saturation levels checked using an oximeter. The final component of testing, the Wisconsin Card Sorting Test, was administered as a posttest within 10-15 minutes of completion of the Multistage 20 Meter Shuttle Run before resting heart rate was achieved.

## Discussion

The results of this study did not indicate a significant relationship in time of day and diurnal preference on executive function when exposed to vigorous activity. Results indicated that participants scored slightly higher in the individual's preferred time than non-preferred time, except in one instance; afternoon participants scored higher in non-diurnal time than did participants in the individual's diurnal preference on the Wisconsin Card Sorting Test-64 pre-test.

Research by Kirby and Kirby (2006) on proactivity suggested that variance on test performance increased by 3% and overall group performance increased by 14%, which could offer some explanation to this discrepancy. The participants may override executive functions based on past experiences which could hinder choice selection (Barbe & Wagner, 2007). Proactivity is the willingness and ability of an individual to take action to change a situation to one's advantage (Kirby & Kirby, 2006). Participant manipulation could have played a role in the reversal of preferred and non-preferred performance. Interindividual differences even though not supported of non-diurnal preference performance, introduced an idea of individuals closely associated with the mean of morningness and eveningness may experience performance confusion related to preferred time (Valdez, Reilly, & Waterhouse, 2008).

Executive function was not affected by testing time alone when exposed to vigorous intensity levels of exercise. Participants showed only slight differences in pretest and posttest scores on the Wisconsin Card Sorting Test-64, which were likely associated with the practice effect. The time limits of one day between testing accentuated the increased likelihood of remembrance in test performance. The extension

of this study over time could possibly yield different results. The condition of vigorous exercise was achieved but should possibly be considered as a main effect in the next study to isolate the effect exercise has on diurnal preferences and executive function (Davranche & Audiffren, 2004).

Executive function did not show a significant relationship when affected by individual diurnal preferences (morningness/eveningness) when exposed to vigorous intensity levels of exercise. Participants' performance scores were slightly higher in the individuals' preferred time, except for the anomaly of nondiurnal preference scoring of afternoon students on the Wisconsin Card Sorting Test-64 pretest. Except for the anomaly, individuals did perform better in each individual's diurnal preference time, which is supportive of research (Carskadon et al., 1993; Wolfson & Carskadon, 1998). The practice effect was evident in preferred preference and possible internal (Kirby & Kirby, 2006; Valdez et al., 2008) and/or environmental factors (Thomas et al., 2000) affected the outcome the anomaly of higher scoring of the reversed preference of afternoon students on the Wisconsin Card Sorting Test-64. Intrinsic period differences (Duffy et al., 2001) can influence diurnal preferences, which could ultimately affect performance.

The interaction of time of day and diurnal preference (morningness/eveningness) on executive function when exposed to vigorous intensity levels of exercise did not present any significant findings. This study did not support findings of academic performance improvement based on time of day and preference (Folkard, 1979; Hines, 2004; Klein, 2004; Kubow, Wailstrom & Bemis, 1999). The relativity of participants' scores to each other depicted little differences between testing at preferred and



nonpreferred times. Research by Kubow, Wailstrom and Bemis, (1999) suggests a biological index that children naturally perform better in the morning hours than do adolescents. This may offer an explanation to overall better performance occurring in the morning instead of the afternoon since the sample size consisted of sixth graders. A pictorial representation of this interaction showed a slight interaction, which could be enhanced by increased sample size. This will warrant further study to conclude this assumption.

### Conclusions

Research supports circadian phasing (Carskadon et al., 1993; Guthrie et al., 1995) and exercise (Davranche & Audiffren, 2004; Dwyers et al., 2001; Field et al., 2001; Sallis et al., 1999; Shephard, 1996) on academic performance, but this study did not find evidence to support the conclusion of other researchers. This study was designed to find the effect of time of day and diurnal preference (morningness/eveningness) on executive function when exposed to vigorous exercise conditions, but did not find any significance in this relationship. The possibility of sample size and practice effect conditions could be altered, which possibly could yield other results in future studies.

### Limitations

The participant pool for this study was chosen from two southern parishes in Louisiana and limited to grade 6 during the winter and spring semesters, so generalizations of other grades, locations, and time of year cannot be made. Although used descriptively in this study gender and ethnicity (Rothstein & Jacobsen, 2006) were not considered variables of measurements in determination of executive function performance on the Wisconsin Card Sorting Test. Socioeconomic status (Rothstein &

Jacobsen, 2006) was not used in determining the variability of executive function performance on the Wisconsin Card Sorting Test. The participants were not evaluated on fitness levels before the administration of the Multi-Level 20 Meter Shuttle Run, so individual intensity performance levels could be hindered. Differences in surface areas could impede the level of performance due to slippage. Core body temperature is a zeitgeber for circadian rhythm; but due to the intrusiveness of the measure, the rise in body temperature created during exercise was not determined or controlled. Practice effect on the Wisconsin Card Sorting Test cannot be eliminated from this study due to the proximity of testing dates. The alternation or lack of student bedtimes was not considered in this study; thus a possible impact on diurnal preference has to be considered.

#### Recommendations for Policies and Practices

The liabilities of No Child Left Behind and the lack of change in the overall educational system since the 1950s have prompted educational leaders to consider new avenues of learning. Educators have to create visual imagery in order to promote change to education that stakeholders can grasp. PL 107-110, the No Child Left Behind Act of 2001, is a federally mandated accountability system based on standards, attendance, and dropout rate with an emphasis of mathematics, reading, or language arts that requires Adequate Yearly Progress (AYP) for educational institutions (<http://www2.ed.gov>). Targeted grant and allocation programs, such as Reading First, William F. Goodling Even Start Family Literacy Programs, and Improving Literacy through School Library Programs, that are listed in the No Child Left Behind Act (2001) restrict state and local funding toward specified programs considered high priority by the Act

(<http://www2.ed.gov>). These financial constraints play a large role in educational choices of administrators in the construction of an educational system designed for the learner of today. These educational constraints could be seen as barriers to broaden, not ones to decrease the educational gap (Figlio & Winicki, 2002; Geierstanger et al., 2004; Rothstein & Jacobsen; 2006; Rouse et al., 2007). The value of broadening the scope from the three components of reading, language arts, and mathematics to that of embodying the entire learner has not been overlooked by the accountability system of California. By law (*Education Code* Section 60800), all school districts in California are required to administer the Physical Fitness Test annually to all students in grades 5, 7, and 9. This broadened scope provides educational leaders with an example of an accountability system that embodies the whole learner.

Literature supports the correlation of the benefits of a healthy body on academic performance (Geierstanger et al., 2004; Reed et al., 2010). An understanding by administrators of the intertwining of physiological and psychological importance for improved academic performance will continue to widen the possibilities for education. Neurobiological stimulation triggered by exercise increases neural growth that can be reshaped and pruned according to experiences and increases academic potential (Jensen, 1998; Willis, 2008). The oxidative breakdown of glucose produces energy to stimulate cognitive functions (Sohn et al., 2005), thus supporting the benefits of exercise to learning. Administrators have to consider the literature and develop exercise opportunities to afford students the opportunity for physiological stimulation to aid psychological improvement. Budgetary constraints enhanced by accountability and political pressures do not have to eliminate programs providing physiological benefits.

First, a plan of action designed to improve the opportunities for exercise during and after school hours has to be in place to enable wise personnel and budgetary considerations. Funding consideration for administrators to increased physical activity is available through the Carol M. White Physical Education Program under Title X of the Elementary and Secondary Education Act

(<http://www2.ed.gov/programs/whitephysed/index.html>), Head Start Body Start, and ING Run for Something Better (<http://www.aahperd.org/naspe/grants/grants/>).

Programs of suggestion for school leaders include interscholastic sports, intramurals, physical activity clubs, walk and bike programs, interscholastic sports, and community use facilities physical activity programs. Knowledge of intensity levels of exercise for improved academic improvement will lead administrators to informed decisions for viable physical activity programs that promote cognition improvement. Relative intensity of exercise is achieved when the body exhausts 60 to 84% of a person's aerobic capacity, which is linked to higher-order cognitive skills (Chang & Etnier, 2009). The American Heart Association's suggestions for vigorous activities include brisk walking, hiking, stair climbing, aerobic exercise, running, biking, swimming, soccer, and basketball. Moderate intensity levels of exercise can be achieved by dancing, tennis, racquetball, and touch football.

School systems have contact with large numbers of children on a routine basis. This makes the school system a natural means of fighting and controlling obesity. The Centers for Disease Control provide funding to school systems to combat physical inactivity and obesity. There is a direct link to unhealthy children and reduced academic performance is obesity (Patrick et al, 2006; Reed et al., 2010; Torre et al., 2010).

Educational systems with enhance physical educational programs can also combat psychological programs through a well-developed physical education program.

Educational leaders also should pursue the biological component of natural circadian rhythm and diurnal preference to enhance student academic performance and impact the standards of No Child Left Behind legislation. Research supports that delayed start times and preferential scheduling can improve absenteeism, dropouts, and improved academic performance (Wolfson, & Carskadon, 2005; Wolfson et al., 2007). Wolfson and Carskadon (2005) offered school administrators a list of recommendations for changing start times of schools, such as educating the community, district-wide stakeholder assessments, school scheduling options, sleep evaluations relating to student absenteeism and attention deficit, sleep curriculum, decreased homework, controlled end times for afternoon activities and athletics, family counseling, adolescent employment hours control, and a positive attitude toward sleep. On a smaller scale, administrators can initiate flexible scheduling of classes and testing schedules to optimize student performance.

#### Recommendations for Future Studies and Research

Future studies and research are recommended to add to research on the effect of time of day on executive function when exposed to vigorous activity conditions. The participants for this study were a convenience sample, instead of a random sample chosen on a voluntary basis. Replication of this study with a larger sample size of participants in the state of Louisiana or the southern portion of the United States would enable more generalization of results. This study included a majority minority population of 65% African American participants. Future research should explore a more heterogeneous

sample of sixth graders. Gender was used as descriptive in this study, but diurnal preference differences were not examined based on differences in sexes.

Considering the viable information on delayed start times and diurnal preference for improved academic performance (Wolfson & Carskadon, 2005; Wolfson et al., 2007) relative to components of PL 107-110, the No Child Left Behind Act of 2001, future research should be examined. The instrument of diurnal preference identification for this study was the Morningness/Eveningness Scale for Children, which was an appropriate measure for diurnal preference for age group identified in this study, but more extensive means of assessment could include continuous monitoring and daily diaries (Acebo, Sadeh, & Seifer, 1999; Wolfson et al., 2003). Parental influence or awareness of sleeping patterns contributes to varied bedtimes which results in non-controlled bedtimes. Bedtimes have an influential effect on rising times and performance alertness so further research is needed to control this factor (Amschler & McKenzie, 2005). The school day schedule for testing was not representative of true morningness and eveningness. A wider range between testing for morningness and eveningness is recommended. Core temperature is a phase marker for circadian rhythm depicting minimal and maximal changes for each individual's performance, thus rectal thermometers would provide specific body temperature changes (Waterhouse et al., 2005).

Prior fitness levels were not ascertained nor were allotted days of physical education per week for each student, thus vigorous activity levels were attained and maintained at uncontrollable levels. The facility of testing fluctuated with each school. Further research in a climate controlled, more regimented conditions would provide more concrete results with less uncontrolled factors. Regimented controls such as laboratory

conditions where intensity levels of activity and oxygen intake could be stimulated using cycle ergometers, treadmills with heart monitors, and/or oxygen induced mask.

The Wisconsin Card Sorting Test was a reliable and valid means of testing executive function (Cianchetti et al., 2007; Feldstein et al., 1999; Lemmink et al., 2004; Vayalakkara et al., 2000), but mixed research suggests Flankers test or Go/No Go paradigm test for executive function is more applicable due to compatibility with neuroimaging or electroencephalographic techniques (Colcombe et al., 2006; Etiner & Chang, 2009). Research indicates that there are age-related changes in executive function skills (Dempster, 1992), but age-related changes were not a consideration in this study. Magnetic Resonance Imaging would enhance results of all three components of this study, thus presenting a more scientific study of time of day effects on executive function under vigorous exercise conditions.

APPENDIX A

MORNINGNESS/EVENINGNESS QUESTIONNAIRE USE AND REPLICATION

PERMISSION REQUEST

The University of Southern Mississippi Mail - MESC Questionnaire

Page 1 of 2



Janie Ryland <janie.ryland@eagles.usm.edu>

## MESC Questionnaire

5 messages

**Janie Ryland <janie.ryland@eagles.usm.edu>**  
To: Mary\_Carskadon@brown.edu

**Thu, Mar 31, 2011 at 7:48 PM**

Dr. Carskadon,  
My name is Janie Ryland. I am a doctoral student at The University of Southern Mississippi. I would like to request permission to use the morningness-eveningness questionnaire for children in my research. The research group involves 6th graders in two Southern Parishes in Louisiana. The research questions focus on the affects on executive function based on diurnal preferences when exposed to vigorous intensity levels of exercise. I would appreciate your consideration in the use of the MESC questionnaire in my research.  
Thank you,  
Janie Ryland

**Carskadon, Mary <mary\_carskadon@brown.edu>**  
To: Janie Ryland <janie.ryland@eagles.usm.edu>

**Sun, Apr 3, 2011 at 5:05 PM**

Hello. Yes, please feel free to use the questionnaire. Sounds like an interesting project.  
Good luck.

Mary A. Carskadon, PhD

[Quoted text hidden]

--  
Mary A. Carskadon, PhD  
Professor, Psychiatry & Human Behavior  
The Alpert Medical School of Brown University

Sleep for Science Research Lab of Brown University  
300 Duncan Drive  
Providence, RI 02906  
USA  
Tel. 401-421-9440  
Fax. 401-453-3578

**Janie Ryland <janie.ryland@eagles.usm.edu>**  
To: "Carskadon, Mary" <mary\_carskadon@brown.edu>

**Mon, Apr 11, 2011 at 8:57 AM**

Thank you,  
Janie Ryland

[Quoted text hidden]

**Janie Ryland <janie.ryland@eagles.usm.edu>**  
To: "Carskadon, Mary" <mary\_carskadon@brown.edu>

**Fri, Jul 15, 2011 at 12:53 PM**

Dr. Carskadon I appreciate the use of your morningness/eveningness questionnaire and would like to request permission to put a replicated copy of the questionnaire with and without scoring key into my final dissertation for publication.  
Thank You,



Janie Ryland

[Quoted text hidden]

---

**Carskadon, Mary** <mary\_carskadon@brown.edu>  
To: Janie Ryland <janie.ryland@eagles.usm.edu>

**Fri, Jul 15, 2011 at 1:16 PM**

Hi Janie. As long as you cite the original article, that should be just fine. MAC

[Quoted text hidden]

Director, Chronobiology & Sleep Research  
EP Bradley Hospital

[Quoted text hidden]

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## APPENDIX B

## HUMAN SUBJECTS PROTECTION REVIEW COMMITTEE PERMISSION




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**THE UNIVERSITY OF SOUTHERN MISSISSIPPI**


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Institutional Review Board

118 College Drive #5147  
 Hattiesburg, MS 39406-0001  
 Tel: 601.266.6820  
 Fax: 601.266.5509  
 www.usm.edu/irb

**HUMAN SUBJECTS PROTECTION REVIEW COMMITTEE  
 NOTICE OF COMMITTEE ACTION**

The project has been reviewed by The University of Southern Mississippi Human Subjects Protection Review Committee in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months. Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **11040102**

PROJECT TITLE: **Circadian Rhythm/Vigorous Activity: Do They Make a Difference on Executive Function**

PROPOSED PROJECT DATES: **02/14/2011 to 02/14/2012**

PROJECT TYPE: **Dissertation**

PRINCIPAL INVESTIGATORS: **Janie Ryland**

COLLEGE/DIVISION: **College of Education & Psychology**

DEPARTMENT: **Educational Leadership & School Counseling**

FUNDING AGENCY: **N/A**

HSPRC COMMITTEE ACTION: **Expedited Review Approval**

PERIOD OF APPROVAL: **04/18/2011 to 04/17/2012**

*Lawrence A. Hosman*  
 \_\_\_\_\_  
 Lawrence A. Hosman, Ph.D.  
 HSPRC Chair

*4-19-2011*  
 \_\_\_\_\_  
 Date

## APPENDIX C

## PRINCIPAL CONSENT LETTER

Upon approval of The University of Southern Mississippi's Institutional Review Board (IRB), Janie Ryland has my permission to survey and test sixth graders at St. Amant Middle School in order to collect data for her research project relating to the effects of physical education and circadian rhythm on academic performance.

I understand that all participation is voluntary and that individual responses will be kept confidential. Further, any changes in the research protocol must be approved by The University of Southern Mississippi Institutional Review Board.

\_\_\_\_\_, Principal  
St. Amant Middle School

## APPENDIX D

CIRCADIAN RHYTHM UNDER VIGOROUS ACTIVITY CONDITIONS: DOES IT  
MAKE A DIFFERENCE ON ACADEMIC PERFORMANCE?

## Physical Educator Instructions

The purpose of the questionnaire is to draw a connection between physical activity levels and sleep patterns with testing scores. Enclosed in the envelopes are parent consent letters, student assent letters, and questionnaires for grade 6. The physical education instructions will be informed of the ethic responsibilities of their project. The P.E instructors are to distribute the questionnaires to the P.E. students who have the proper signed consent forms. The students are to read each of the statements on the questionnaire and circle the answer which each student feels is correct. The physical education instructor is to remind the students before beginning the questionnaire, the Wisconsin Card Sorting Test, multilevel shuttle run, and oximeter test, it is voluntary and confidential. After completing each phase of the experiment, materials are returned to their P.E. instructor. The completed questionnaires, Wisconsin Card Sorting 64 test results, Multi-level 20m shuttle run results, oximeter results, and consent forms are to be returned in the provided envelopes and sealed. The physical education instructor will return the above materials at the completion of the experiment. The researcher will return to pick up the envelopes on the final day of testing.

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Name of School

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P.E. Instructor

## APPENDIX E

## PARENTAL CONSENT FORM

As a student in elementary grade 6 in St. James Parish, your child has been chosen to participate in a study to determine ways of improving academic performance. I, Janie Ryland, a teacher in St. James Parish and student at The University of Southern Mississippi, am asking for your permission to give your child the Wisconsin Card Sorting computerized test, shuttle run test and, for a chosen few, an oximeter test. The data will be kept secret and destroyed at a later date when the information is no longer useful for study. The information from the data will be used to look at how sleep patterns and physical activity could affect academic performance.

The information collected will be used to determine the effects of physical activity and sleep patterns on improved academic performance, which could affect class scheduling and levels of physical activity. The results of the data will be at each elementary school office for you to see at the end of the study.

This form must be signed and returned in order for your child to participate in the study. This project is strictly voluntary, and your child's grade will not be affected by not participating. The process involves the use of a computerized test and shuttle run which have no identifying names. There are no known risks for your child's participation in the Wisconsin Card Sorting computerized test and the oximeter test. Precautions for the shuttle run are limited. The student will be allowed to stop the shuttle run at any point, and a certified nurse will be on site during the activity.

Any questions relating to the details of the study will be addressed by Janie Ryland at jryland@stjames.k12.la.us. This is an approved IRB research project at The University of Southern Mississippi.

Thank you for your support,

Janie Ryland

"This project has been reviewed by the Human Subjects Protection Review Committee, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research subject should be directed to the chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS 39406-0001, (601) 266-6820."

I, \_\_\_\_\_, give my permission for my child  
 Print your first name and last name here  
 to participate in this research study.

\_\_\_\_\_  
 Sign your name here

\_\_\_\_\_  
 Date

## APPENDIX F

## STUDENT ASSENT LETTER

I, Janie Ryland, am a teacher in St. James Parish and a student at The University of Southern Mississippi. I am asking your P.E. instructor, myself, and nursing volunteers to give you a Morningness/Eveningness Scale for Children questionnaire, Wisconsin Card Sorting computerized test and a multi-stage 20 m shuttle run test. The testing procedure will take 3 days. The first day will consist of a morningness/eveningness questionnaire. The second day will consist of a Wisconsin Card Sorting 64 computerized test. The third day consists of participation in the multi-stage 20 m shuttle run test, and within 10-15 minutes of completion of the shuttle run you will take the Wisconsin Card Sorting 64 computerized test again. A random selected few will be given an oximeter test to show the amount of oxygen in the body after the multi-level shuttle run. The morningness/eveningness questionnaire will take about 15 minutes. The computerized test will take approximately 12- 20 minutes. The shuttle run will take about 10-15 minutes to complete.

You are being asked to participate in this study because you are in an elementary P.E. class in Ascension Parish. You will be asked to fill out a questionnaire in your P.E. class and return the completed questionnaire to your P.E. instructor, myself, or the nurse volunteers when you have finished the questionnaire on Day 1. You can choose to fill out the questionnaire or choose not to fill out the questionnaire. On Day 2 and 3 you will participate in Wisconsin Card Sorting test and a shuttle run. You can choose not to take the Wisconsin Card Sorting Test 64 computerized test and/ or the multi-level shuttle run. All results of the experiment will be kept secret. This project will have no effect on your P.E. class or grades.

Participation will aid research to determine if P.E. and sleep patterns have an effect on your testing performance. This research could have a possible effect on class scheduling and levels of activity provided. This is a voluntary project, which promotes limited risks to you the participant.

If you have any questions, you can contact Janie Ryland at [jryland@stjames.k12.la.us](mailto:jryland@stjames.k12.la.us). If you would like to see the results of the study, a copy will be available in the school's office.

I, \_\_\_\_\_, want to be in this research study.

Print your first name and last name here

\_\_\_\_\_  
Sign your name here

\_\_\_\_\_  
Date

## APPENDIX G

## MESG AS GIVEN TO STUDENTS

NAME \_\_\_\_\_ PERIOD \_\_\_\_\_

- \_\_\_\_\_ 1) Imagine: School is canceled! You can get up whenever you want to. When would you get out of bed? Between ...
- 5:00 and 6:30 am
  - 6:30 and 7:45 am
  - 7:45 and 9:45 am
  - 9:45 and 11:00 am
  - 11:00 am and noon
- \_\_\_\_\_ 2) Is it easy for you to get up in the morning?
- No way!
  - Sort of
  - Pretty easy
  - It's a cinch
- \_\_\_\_\_ 3) Gym class is set for 7:00 in the morning. How do you think you'll do?
- My best!
  - Okay
  - Worse than usual
  - Awful
- \_\_\_\_\_ 4) The bad news: You have to take a two-hour test. The good news: you can take it when you think you'll do your best. what time is that?
- 8:00 to 10:00 am
  - 11:00 am to 1:00 pm
  - 3:00 to 5:00 pm
  - 7:00 to 9:00 pm
- \_\_\_\_\_ 5) When do you have the most energy to do your favorite things?
- Morning! I'm tired in the evening
  - Morning more than evening
  - Evening more than morning
  - Evening! I'm tired in the morning
- \_\_\_\_\_ 6) Guess what? Your parents have decided to let you set your own bedtime. What time would you pick? Between ...
- 8:00 and 9:00 pm
  - 9:00 and 10:15 pm
  - 10:15 pm and 12:30 am
  - 12:30 and 1:45 am
  - 1:45 and 3:00 am
- \_\_\_\_\_ 7) How alert are you in the first half hour you're up?
- Out of it
  - A little dazed
  - Okay
  - Ready to take on the world
- \_\_\_\_\_ 8) When does your body start to tell you it's time for bed (even if you ignore it)? Between ...
- 8:00 and 9:00 pm
  - 9:00 and 10:15 pm
  - 10:15 pm and 12:30 am
  - 12:30 and 1:45 am
  - 1:45 and 3:00 am
- \_\_\_\_\_ 9) Say you had to get up at 6:00 am every morning: What would it be like?
- Awful!
  - Not so great
  - Okay (if I have to)
  - Fine, no problem
- \_\_\_\_\_ 10) When you wake up in the morning how long does it take for you to be totally "with it?"
- 0 to 10 minutes
  - 11 to 20 minutes
  - 21 to 40 minutes
  - More than 40 minutes

## APPENDIX H

## MESC WITH SCORING CODE

- \_\_\_\_\_ 1)\* Imagine: School is canceled! You can get up whenever you want to. When would you get out of bed? Between ...
- 5:00 and 6:30 am
  - 6:30 and 7:45 am
  - 7:45 and 9:45 am
  - 9:45 and 11:00 am
  - 11:00 am and noon
- \_\_\_\_\_ 2) Is it easy for you to get up in the morning?
- No way!
  - Sort of
  - Pretty easy
  - It's a cinch
- \_\_\_\_\_ 3)\* Gym class is set for 7:00 in the morning. How do you think you'll do?
- My best!
  - Okay
  - Worse than usual
  - Awful
- \_\_\_\_\_ 4)\* The bad news: You have to take a two-hour test. The good news: you can take it when you think you'll do your best. What time is that?
- 8:00 to 10:00 am
  - 11:00 am to 1:00 pm
  - 3:00 to 5:00 pm
  - 7:00 to 9:00 pm
- \_\_\_\_\_ 5)\* When do you have the most energy to do your favorite things?
- Morning! I'm tired in the evening
  - Morning more than evening
  - Evening more than morning
  - Evening! I'm tired in the morning
- \_\_\_\_\_ 6)\* Guess what? Your parents have decided to let you set your own bedtime. What time would you pick? Between ...
- 8:00 and 9:00 pm
  - 9:00 and 10:15 pm
  - 10:15 pm and 12:30 am
  - 12:30 and 1:45 am
  - 1:45 and 3:00 am
- \_\_\_\_\_ 7) How alert are you in the first half hour you're up?
- Out of it
  - A little dazed
  - Okay
  - Ready to take on the world
- \_\_\_\_\_ 8)\* When does your body start to tell you it's time for bed (even if you ignore it)? Between ...
- 8:00 and 9:00 pm
  - 9:00 and 10:15 pm
  - 10:15 pm and 12:30 am
  - 12:30 and 1:45 am
  - 1:45 and 3:00 am
- \_\_\_\_\_ 9) Say you had to get up at 6:00 am every morning: What would it be like?
- Awful!
  - Not so great
  - Okay (if I have to)
  - Fine, no problem
- \_\_\_\_\_ 10)\* When you wake up in the morning how long does it take for you to be totally "with it?"
- 0 to 10 minutes
  - 11 to 20 minutes
  - 21 to 40 minutes
  - More than 40 minutes

Morningness/eveningness scale for children. A score is derived by adding points for each answer: a=1, b=2, c=3, d=4, e=5, except as indicated by \*, where point values are reversed. The maximum score is 42 (maximum morning preference) and the minimum is 10 (minimal morning preference).

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