The Effects of Aerobic Exercise and Resistance Exercise on the Cognitive Function of the Human Population

Alexandra Jillson

Lasell College

Introduction

The prevalence of physical inactivity among human beings globally is growing day by day, turning into a pandemic where over 3 million lives are claimed prematurely worldwide each year (Pratt, Norris, Lobelo, Roux, & Guijing, 2014; Staniano et al., 2012). According to Pratt et al. (2014), the World Health Organization has deemed physical inactivity to be, "the fourth leading underlying cause of mortality" (Pratt et al., 2014, p. 1). The increases in the prevalence of physical inactivity can be closely linked to the general attitudes of human beings choosing to live sedentary lifestyles where daily measurements of low energy expenditure are common (Rhodes & Dean, 2009; Rosenberg, Bull, Marshall, Sallis, & Bauman, 2008). The human behavior of choosing to live a sedentary lifestyle instead of being physically active also has been linked to the advances in technology which associate leading a sedentary lifestyle as an enjoyment (Rhodes & Dean, 2009; Rosenberg et al., 2008). Examples of advances in enjoyable technology having been found to support a sedentary lifestyle are the television, car, and computer, where each promote prolonged periods of sitting and physical inactivity (Rhodes & Dean, 2009; Rosenberg et al., 2008). The lack of physical activity promotes premature death and is associated with other detrimental diseases which in reality may have been preventable (Donlec & Petric, 2013; Pescatello, Arena, Reibe, & Thompson (Eds.)., 2013; Pratt et al., 2012; Rhodes & Dean, 2009; Rosenberg et al., 2008; Staniano et al., 2012; Vuori, 2004).

Physical inactivity has been shown throughout research to promote the development of metabolic syndrome, cardiovascular disease, different cancers, obesity, and decreases in bone density and musculature health (Pescatello et al. (Eds.)., 2013; Pratt et al., 2012; Rhodes & Dean, 2009, Rosenberg et al., 2008, Staniano et al., 2012, Vuori et al., 2004). Spending more time sedentary has been found to increase the likelihood of other factors of an unhealthy lifestyle, such as a poor diet, smoking, and the consumption of alcohol, lack of which further promotes the development of the associated diseases and health risks (Pescatello et al. (Eds.)., 2013; Vuori et al., 2004). Another essential aspect of human health effected by a sedentary lifestyle and physical inactivity which is often left undiscussed is cognitive function (Dolenc & Petric, 2013; Kesse-Guyot, Andreeva, Lassale, Hercberg, & Galan, 2014; Pescatello et al. (Eds.)., 2013; Vuori, 2004). Cognition plays a major role in the functions of daily living of human beings and correlations between physical inactivity and adverse effects on cognitive function have been made throughout research (Dolenc & Petric, 2013, Kesse-Guyot et al., 2013, Pescatello et al. (Eds.)., 2013). Although physical inactivity has been proven to have numerous detrimental effects on the human body, becoming and staying physically active has been shown throughout research to prevent the detrimental effects and prevent cognitive decline (Dolenc & Petric, 2013; Pescatello et al. (Eds.)., 2013; Pratt et al., 2012; Staniano et al., 2012; Vuori et al., 2004).

Participating in a minimum of at least 150 minutes of physical activity has been shown to prevent and even reverse the development of the diseases associated with physical inactivity, as well as promote cognitive function and health (Pescatello et al. (Eds.)., 2013; Staniano et al., 2012; Vuori et al., 2004). Furthermore, surpassing the minimal amounts of physical activity each week and the addition of regular exercise has shown further benefits for the human body and cognitive function (Bielak et al., 2014; Dishman et al., 2006; Kenji et al., 2014; Kleim, 2011; Kravitz, 2011; Marmeleira, 2013; Pescatello et al. (Eds.)., 2013). The purpose of this literature review is to provide a better understanding of general exercise and the associated benefits, aerobic exercise, resistance exercise, cognitive function, and how aerobic exercise and resistance exercise effect cognitive function individually as well as together

Exercise

Participating in exercise and staying physically active are both strong recommendations made by health and fitness professionals on a regular basis (Kravitz, 2011; Pearce, 2008; Pescatello et al. (Eds.)., 2013; Pollack et al., 2008). The terms “exercise” and “physical activity”, although related, are commonly mistaken to have the same meaning as each other. (Pescatello et al. (Eds.)., 2013). The American College of Sports Medicine defines physical activity as, “any bodily movement that result in a substantial increase in caloric requirements over resting energy expenditure” (Pescatello et al. (Eds.)., 2013, p.2). Exercise on the other hand is referred to as a component of physical activity where the goal is to improve physical fitness through planned, structured, and repetitive body movements (Kravitz, 2011).

Regular exercise alone can produce an endless amount of benefits for the human body such as a reduction in total body fat, a reduction in systolic and diastolic blood pressure readings, a reduction in death rates from coronary artery disease, a decreased risk of developing certain cancers, and an enhancement in the feelings of well-being and cognitive function (Kravitz, 2011; Pearce, 2008, Pescatello et al. (Eds.), 2013). The frequency of exercise, the duration of exercise, and the degree of effort a person dedicates to exercise dictates how substantial the benefits of exercise will be for the human body (Pescatello et al. (Eds.)., 2013; Pollack et al., 2008). Two both common and well-known ways to participate in exercise is through aerobic exercise and resistance exercise.

Aerobic Exercise

Aerobic exercise, often referred to as “cardio”, predominately utilizes the body’s cardiorespiratory system in order to provide essential amounts of oxygen and nutrients to the body in aid of sustaining the exercise (Clark, Lucett, & Corn (Eds.)., 2013). Aerobic exercise can be performed in many different modes which contributes to the popularity of the exercise for active individuals. Common forms of aerobic exercise are walking, running, cycling, swimming and hiking (Baechle & Earle (Eds.)., 2008; Pearce, 2008). Aerobic exercise in general induces a chain of effects which sequentially prepare the body to sustain the aerobic activity being performed (Baechle & Earle (Eds.)., 2008; Clark et al. (Eds.)., 2013; McArdle, Katch, F., Katch, V., 2014; Pearce, 2008).

The first effect which occurs during the initial start of aerobic exercise takes place within the body's energy systems. ATP, which stands for adenosine triphosphate, is a form of metabolic energy within the body needed to initiate and sustain movement and exercise (Clark et al (Eds.)., 2013; Pearce, 2008; Wyon, 2005). The ATP-PCR energy system provides the initial source of ATP and begins to deplete during the first minute of activity (Pearce, 2008; Clark et al. (Eds.)., 2013; Wyon, 2005). In order for the body to continue to perform without fatiguing, other energy systems within the body begin to take over and meet the energy demands of the exercise (Clark et al (Eds.)., 2013; McArdle, Katch, F., Katch, V., 2014; Wyon, 2005). After the ATP-PCR system depletes, the glycolytic energy system begins to take over and supply the body with energy for a duration of two to five minutes through the utilization of glucose stores within the muscles and the liver (Clark et al (Eds.)., 2013; Wyon, 2005). After the glycolytic energy system exhausts and fades out, the oxidative energy system begins to produce an ample amount of ATP through the fuel sources of fats, proteins, and carbohydrates (McArdle et al., 2014; Pearce, 2008). The oxidative energy system can provide the body with a sustained amount of energy for a continuous amount of time during low intensity activity due to the ample fat storage within the human body (Clark et al (Eds.)., 2013; Pearce, 2008; Wyon, 2005). The bodies energy systems are the underlying power houses which aid in providing a proficient amount of energy in order to sustain exercise metabolically (Clark et al (Eds.)., 2013; McArdle et al., 2014; Pearce, 2008; Wyon, 2005). In addition to the energy systems within the body, other bodily systems are also functioning in order to sustain the aerobic exercise being performed.

While the bodies energy systems are working during aerobic exercise, the cardiovascular system is also working to meet the physiological demands placed on the body. During aerobic exercise, the cardiovascular system functions to deliver the required amounts oxygen and nutrients to the active muscles through the blood in order to keep the body moving and the exercise sustained (Baechle & Earle (Eds.)., 2008). An increase in heart rate, systolic blood pressure and filling rates, cardiac output and stroke volume, and the velocity of the blood circulating throughout the body contributes to the delivery rate of the oxygen and nutrients (Dickhuth, Scharhag, Röcker, & König, 2012; Figoni, Phillips, & Scremin, 2012). Each of the mentioned biological responses are dependent on the intensity of the aerobic exercise being performed (Baechle & Earle (Eds.)., 2008). In other words, the higher the intensity of the aerobic exercise, the higher the increase in the hearts cardiac output, stroke volume, and heart rate response in order to meet the demands placed on the body due to the aerobic exercise intensity.

In addition to the body's cardiac response to aerobic exercise, the respiratory system also has a significant response to aerobic exercise (Baechle & Earle (Eds.)., 2008). Oxygen uptake and carbon dioxide production increases in conjunction with the intensity of the aerobic exercise in order to keep the body from fatiguing and to keep the exercise sustained (Baechle & Earle (Eds.)., 2008; Coyler, 2013). In addition, the circulating blood within the body absorbs the oxygen inspired and becomes oxygenated (Colyer, 2013). The oxygenated blood then travels throughout the body and to different bodily tissues in order to adequately supply oxygen to prevented fatigue (Colyer, 2013). The increases in carbon dioxide production occur due to an increased respiratory rate (Baechle & Earle (Eds.)., 2008; Colyer, 2013). The excess amounts of carbon dioxide within the body begins to be filtered out within the circulating blood through a process of diffusion, where the carbon dioxide is brought back to the lungs and is released through the process of exhalation (Baechle & Earle (Eds.)., 2008; Colyer, 2013). Both the processes of bringing oxygen to the anticipated tissues and the removal of carbon dioxide from the body work together in order to prevent fatigue and enhance the toleration of the aerobic exercise being performed. In addition to the different bodily functions occurring during aerobic exercise, other adaptions occur within the body as a result of repetitive aerobic exercise (Pearce, 2008).

Over a prolonged training program involving aerobic exercise a series of chronic adaptations occur within the body's cardiovascular system, respiratory system, and muscular system as a result (Pearce, 2008). The chronic adaptations include a reduced resting heart rate and working heart rate, increased cardiac output, decreased blood thickness, an increase in lung tidal volume, a decreased resting respiratory rate, and an increase in muscular productivity (Pearce, 2008). The different adaptations to aerobic fitness training become noticeable within several weeks from the start of the exercise program if the program remains consistently regimented (McArdle et al., 2014). In addition to the chronic adaptations to aerobic exercise, additional health benefits can result from participating in aerobic exercise as well (McArdle et al., 2014; Pollack et al., 1998). Researchers have discovered participating in an aerobic exercise training program promotes longevity, reduces death rates by nearly 50% for those who have hypertension, reduces the risk of the development of chronic diseases, reverses the negative effects of cigarette smoking and excessive body fat on the body, increases the rate of metabolic metabolism, and reduces the mortality rate caused by significant health risks by nearly 25% (McArdle et al., 2014; Pollack et al., 1998). The results of different research studies have also shown exercising at a relatively higher aerobic intensity level has greater impacts on overall cardiovascular health and weight loss (Wallman, Plant, Rakimov, &Maiorana, 2009). Exercising at a relatively lower aerobic intensity level has been determined to have similar health benefits in addition to less overall physical stress placed on the joints of the lower limbs (Wallman et al., 2009).

Overall, aerobic exercise induces numerous physiological effects and adaptations within the body in order to prevent fatigue and promote the ability to sustain the exercise for a prolonged period of time (Baechle & Earle, (Eds.)., 2008; Clark et al (Eds.)., 2013; Colyer et al., 2013; Dickhuth et al., 2012; Figoni et al., 2012; McArdle et al., 2014; Pearce, 2008; Pollack et al., 1998). In addition to the physiological effects and adaptions, the health benefits associated with a prolonged aerobic exercise program are extremely beneficial for the human body (McArdle et al., 2014; Pollack et al., 1998; Wallman et al., 2009). Similar to the physiological effects, adaptions, and health benefits of aerobic exercise, comparable physiological effects, adaptations, and health benefits can also be identified with performance of resistance exercise.

Resistance Exercise

Resistance exercise is commonly known as strength training within the fitness world and falls into the category of anaerobic training due the involvement of high intensity and short duration exercise techniques (Baechle & Earle (Eds.)., 2008; Willardson, 2006). Various training modalities can be utilized when participating in resistance exercise, such as body weight, free weights, resistance bands, and stationary machinery (Baechle & Earle (Eds.)., 2008; Clark et al (Eds.)., 2013). Resistance exercise can also be manipulated in order to achieve different training goals, contributing to the uniqueness of resistance exercise (Baechle & Earle (Eds.)., 2008; Willardson, 2006). The different training goals include muscular strength, muscular endurance, muscular hypertrophy, and muscular power (Willardson, 2006). Each training goal can be achieved through the manipulation of the number of sets, the number of repetitions, the duration of rest between the number of sets and repetitions, and the amount of weight that is being applied (Baechle & Earle (Eds.)., 2008; Hoffman (Ed.)., 2012; Willardson, 2006). Similar to aerobic exercise, various effects begin to occur within the body at the initiation of the resistance exercise which begin to prepare the body to sustain the exercise performed.

The initial effect occurring at the start of resistance exercise takes place within the body's energy systems (Baechle & Earle (Eds.)., 2008; Willardson, 2006). As previously mentioned, resistance exercise is considered to be a form of anaerobic training due to the nature of being high in intensity, high in metabolic demands, and short in exercise duration (Baechle & Earle (Eds.)., 2008; Pearce, 2008). The anaerobic properties of resistance training entails the body's anaerobic energy systems, the ATP-PCR energy system and the glycolytic energy system, are going to supply the main sources of energy to meet to the metabolic exercise demands placed on the body (Baechle & Earle (Eds.)., 2008; Pearce, 2008; Willardson, 2006). The reliance of the aerobic energy system during resistance exercise is minimal and if at all, the aerobic energy system may be active within the recovery process after a bout of high intensity exercise (Pearce, 2008; Wallman et al., 2009). The utilization of fats as an energy source, which is the main source of energy for the aerobic energy system, may help to regain energy due to the depletion of glycogen, which is the main fuel source of the of the glycolytic energy system (Wallman et al., 2009). Depending on the training goal, one anaerobic energy system may be favored over the other due to the duration and the intensity of the resistance exercise performed (Baechle & Earle

(Eds.)., 2008; Willardson, 2009). If the training goal is muscular endurance, then the glycolytic energy system will be favored over the ATP-PCR energy system due to the increased number of repetitions (Baechle & Earle (Eds.)., 2008). If the training goal is muscular power, then the ATP-PCR energy system will be favored over the glycolytic system due to the smaller number of repetitions, the increased intensity, and the rest periods of a maximal effort exercise which let the ATP-PCR energy system properly recover (Willardson, 2006). In addition to the body's energy systems contribution to meet the demands of the resistance exercise performed, additional body systems are also functioning and adapting in order to meet the physiological demands of the exercise

Within the body's neuromuscular system, the response to the demands placed on the body is reliant on the specific type of biomechanical movement associated with the exercise, as well as the duration and intensity of the exercise (Tiapale et al., 2015). The results of different research studies have shown notable increases in neural drive and activation within the muscles, as well as an increase in the rate at which force can be developed during the performance of resistance exercise (Aagaard, Simonsen, Andersen, Magnusson, & Dyhre-Poulsen, 2003). Motor neuron firing rate also increases with resistance exercise which allows the targeted muscles to contract at a higher and faster rate to produce the amount of force needed during resistance exercise (Aagaard et al., 2003). The different neuromuscular responses to resistance training also facilitate responses within the muscular system, specifically in the utilization of muscle fiber types and the transition of muscle fiber types (Baechle & Earle (Eds.)., 2008; Bird, Tarpenning, & Marino, 2005; Moore et al., 2004).

The two main types of muscle fibers within the human body are Type I slow twitch muscle fibers and Type II fast twitch muscle fibers. (Bird, Tarpenning, & Marino, 2005; Clark et al (Eds.)., 2013; Moore et al., 2004). Type II fast twitch muscle fibers can be divided into Type IIa and Type IIx muscle fiber sub-category types (Bird et al., 2005; Clark et al (Eds.)., 2013; Moore et al., 2004). Every muscle within the human body contains a combination of each type of muscle fiber, but how the muscle fibers are recruited during exercise is determined by the physiological demands of the exercise (Bird et al., 2005; Clark et al (Eds.)., 2013; Moore et al., 2004). Type I slow twitch muscle fibers are typically activated during low intensity activities and are more resistant to fatigue due to the oxidative properties, whereas Type II fast twitch muscle fibers are typically activated during high intensity activities and fatigue at a quicker rate (Moore et al., 2004). Type IIa muscle fibers, a component of Type II muscle fibers, have both aerobic and anaerobic qualities and tend to have the ability to fatigue at a slower rate, while Type IIx muscle fibers have more anaerobic properties and fatigue at a faster rate (Bird et al., 2005; Clark et al (Eds.)., 2013). Depending on the neuromuscular response to the demands of resistance exercise, Type IIx muscle fibers have the ability to transition into Type IIa muscle fibers (Baechle & Earle (Eds.)., 2008; Bird et al., 2005). Although Type IIa muscle fibers tend to have more oxidative properties, the transitioned Type IIx muscular fibers will still have the ability to produce an optimal amount of force and power, with the added ability to fatigue at a slower rate (Baechle & Earle (Eds.)., 2008). Researchers have discovered the transformation of muscle fibers may result from the energy demands of the resistance exercise, which as mentioned previously, can determine which muscle fiber type is going to be predominantly utilized throughout the exercise (Bird et al., 2005). In addition to the body's neuromuscular and muscular systems response to resistance exercise, other body systems are functioning to perform and meet the demands of the exercise as well.

Additional bodily responses to resistance exercise occur within the cardiovascular system and the respiratory system (Baechle & Earle (Eds.)., 2008; Steele, Fisher, McGuff, Bruce-Low, & Smith, 2012). Within the body's cardiovascular system, significant increases within the hearts cardiac output response, systolic blood pressure, and heart rate response allows for an increase in the amount of blood circulating throughout the body to provide the proper nutrients needed to sustain the resistance exercise performed (Steele et al., 2012). Within the body's respiratory system, notable increases within ventilation during and after a resistance training occur in order to supply the body tissues with the proper amounts of oxygen needed to sustain the resistance exercise (Baechle & Earle (Eds.)., 2008). In addition to the responses to resistance exercise from neuromuscular system, muscular system, cardiovascular system, and respiratory system, additional health benefits can result from a prolonged and consistent resistance training program.

Major health benefits found to result from the participation in resistance exercise include increases in athletic performance levels, a decreased risked for developing debilitating chronic diseases, a reduction in blood pressure, and the prevention of future injuries through the strengthening of bones, ligaments, and muscles (Fisher, Steele, Bruce-Low, & Smith, 2011; Pescatello et al., (Eds.)., 2013). Each health benefit alone can increase the quality of life, longevity, and with ability to manipulate resistance training exercise to obtain different fitness goals, makes resistance exercise a popular form of exercise in addition to aerobic exercise. Although both forms of exercise can affect the body in different ways, one area of human health in which each form of exercise has an influence on is cognition and cognitive function (Dishman et al., 2006; Kenji et al., 2014; Kleim, 2011; Marmeleria, 2013).

Cognition

Cognition describes the ability of the mind to process received information, organize and store the received information, and retrieve the stored information through a series of cognitive functions (Bandura, 1993). The cognitive functions relative to cognition include memory, attention, concentration, reasoning, language, and executive functions (Gujord. Engedal. Bergland, Moger, & Mengshoel, 2014; Kenji et al., 2014). Executive functions are described as advanced cognitive functions including working memory (the ability to recall information in a specific situations), the ability to solve problems, reaction time, and the ability to perform cognitively challenging tasks (Alloway R. & Alloway T., 2015; Gujord et al., 2014; Peiffer, Darby, Fullenkamp, & Morgan, 2015; Pontifex, Hillman, Fernhall, Thompson, & Valentini, 2009). The ability to execute each cognitive function varies primarily by age and the extent of intellectual capacity present (Mercado, 2008). Furthermore, the anatomy and the functions of the human brain have been thoroughly examined to understand the role of the brain within the various executions and limitations within cognition and cognitive functions (Healy & Rowe, 2007; Mercado 2008). The human brain is an extremely complex organ and different parts of the brain play unique roles in cognitive function.

Brain Research – Cognitive Function

The brain is the major organ within the nervous system of the human body with many different sections which control a multitude of bodily functions (Martini, Ober, & Nath, 2011). The cerebrum, cerebellum, and the brain stem are the three major sections of the brain which can be divided into smaller subsections (Martini et al., 2011). Researchers have found the cerebral cortex, the prefrontal cortex, and the hippocampus areas within the brain contribute to the execution of certain cognitive functions and abilities (Christoff, Ream, Geddes, & Gabrieli, 2003; Elliot, 2003; Healy & Rowe, 2007; Hoptman & Davidson, 1994; Kleim, 2011;

Marmeleira, 2013; Pollmann, 2004). Depending on the specific section of the brain, examples of cognitive functions that can be executed include the ability to process sensory information, monitoring auditory information, and cognitive abilities (Healy & Rowe, 2007; Martini et al., 2011).

The cerebral cortex contains over a million neurons and covers the surface of the two cerebral hemispheres in the form of a layer of grey matter (Hagmann et al., 2008; Kleim, 2011; Martini et al., 2011). The two cerebral hemispheres are referred to as the left and right hemisphere where each have separate functions, yet work together (Hoptman & Davidson, 1994; Martini et al., 2011). The left cerebral hemisphere functions to execute writing skills, reading skills, language skills, and tasks requiring logic, speech, and emotion (Hoptman & Davidson, 1994; Martini et al., 2011). The right cerebral hemisphere functions to process sensory information, contributes to attention, and helps the body determine sensory environmental settings (Hoptman & Davidson, 1994; Martini et al., 2011). The cerebral cortex specifically has been noted to be associated with advanced cognitive tasks a part of daily life such as the ability to process, store, memorize, and retrieve specific information (Healy & Rowe, 2007; Kleim, 2011; Martini et al., 2011). Overall, the cerebral cortex is a major component within the brain and plays a significant role in the execution of advanced cognitive tasks that are performed on a daily basis.

In the same way the cerebral cortex plays critical role within the execution of certain cognitive functions, the prefrontal cortex has been found to have a critical role in other aspects of cognitive function (Christoff et al., 2003; Gobet, 2011; Martini et al., 2011; Pollmann, 2004). The prefrontal cortex is located within the frontal lobe of the brain and is a part of both the left and the right hemispheres of the brain. The prefrontal cortex is also part of the integrative center, functioning to perform tasks such as speech (Martini et al., 2011). The role of the prefrontal cortex on cognitive function has been studied by numerous researchers who have suggested the prefrontal cortex is activated during complex cognitive tasks (Christoff et al., 2003; Gobet, 2011; Martini et al., 2011; Pollmann, 2004). The complex cognitive functions include working memory, the ability to control attention, reasoning, the ability to retrieve stored information from long-term memory, decision making, and logic (Christoff et al., 2003; Gobet, 2011; Martini et al., 2011; Pollmann, 2004). This theory is supported by findings of direct damage to the prefrontal cortex resulting in significant impairments within the associated cognitive functions and abilities (Christoff et al., 2003). This discovery demonstrates how essential the prefrontal cortex is during the performance of complex cognitive functions and without the prefrontal cortex, the way humans cognitively function would be significantly affected.

The hippocampus is another essential component of the brain also playing a significant role within cognitive function (Martini et al., 2011; Nadel & Peterson, 2013; Shohamy & Turke-Browne, 2013). The hippocampus is a component of the cerebrum and limbic system, functioning to make a person have the desire to perform a specific cognitive task instead of physically making a person perform a certain cognitive task (Martini et al., 2011). The hippocampus specifically has been suggested to be highly interactive with the other areas of the brain and operates similar to a control system (Nadel & Peterson, 2013; Shohamy & Turk-Browne, 2013). In terms to the involvement of the hippocampus' with cognitive functions, researchers have discovered the hippocampus contributes to the ability to store and retrieve memories, working memory, learning, and perception (Martini et al., 2001; Nadel & Peterson, 2013; Shohamy & Turk-Browne, 2013). The hippocampus has also been indicated to play a role in an array of many other important cognitive functions due to the hippocampus having a connection with other sections of the brain, such as the midbrain and the temporal cortex (Nadel & Peterson, 2013; Shohamy & Turk-Browne, 2013). In other terms, the connection the hippocampus has with other sections of the brain which play a role in cognition and cognitive functions suggests the hippocampus may contribute to additional cognitive functions, a part from the cognitive functions directly performed by the hippocampus (Nadel & Peterson, 2013; Shohamy & Turke-Browne, 2013). The function of the hippocampus is essential to the linked cognition and cognitive functions as well as the separate cognitive functions associated with the other areas of the brain, which are all essential for everyday living.

The brain is a complex organ within the human body and contributes to nearly every single bodily function, especially cognitive function (McArdle et al., 2011). The cerebral cortex, the prefrontal cortex, and the hippocampus are three major components of the brain which significantly control and effect complex cognitive functions and less complex cognitive functions, such as memory, attention control, and information storage, which all are significant to daily living (Christoff et al., 2003; .Elliot, 2003; Gobet, 2011; Healy & Rowe, 2007; Hoptman & Davidson, 1994; Kleim, 2011; Marmeleira, 2013; Nadel & Peterson, 2013; Pollmann, 2004; Shohamy & Turke-Browne, 2013). Although the brain plays an important role within cognitive function, the ability to perform different cognitive functions has been suggested by researchers and research findings to be developed over a period of time (Toplak, West, Stanovich, 2014).

Physiology of Cognitive Function

Researchers have suggested through the findings of numerous research studies, cognitive functions and cognitive abilities are relative to the age of a person (Pureza, Goncalves, Branco, Grassi-Oliveria, & Fonseca, 2013; Toplak et al., 2014). This theory is proposed by the developmental process of the brain, (which previously discussed), has a major contribution in the ability to perform different cognitive functions (Bolema et al., 2014; Pureza et al., 2013). The brain is developed during the stages of childhood, adolescents, and adulthood, each stage determining the extent of which cognitive functions can be performed (Boelema et al., 2014; Pureza et al., 2013). Researchers have suggested a development of baseline level of simpler cognitive functions which coincide with complex cognitive functions have to master prior to the ability to perform the complex cognitive function (Boelema et al., 2014; Pureza et al., 2013). For instance, the ability of goal setting is reliant on simpler cognitive functions such as attention control, the ability to process information, and planning, which are developed and matured as a person ages (Bolema et al., 2014; Pureza et al., 2013). The ability to execute more complex cognitive functions has been suggested by researchers to occur when a person reaches adulthood (Pureza et al., 2013). However, just as cognition and the ability to perform cognitive tasks increases with age and maturation, a decline within cognition and execution of cognitive tasks has been shown to occur as a person enters the later years of life (Boyle et al., 2013; Wilson et al., 2013). Similar to how the human body begins to age and different bodily functions begin to change and diminish, cognition begins to age as well due to a number of different factors.

Cognitive decline can result from numerous factors, such as the slowing of cognitive processes resulting from old age and poor health (Boyle et al., 2013; Hills, Mata, Wilke, & Samanez-Larkin, 2013; Wilson et al., 2013). Researchers have determined, as cognitive function declines, notable increases in the likelihood of a person becoming disabled, passing away, an increase in medical costs, and a decrease in the general state of well-being may occur (Boyle et al., 2013; Wilson et al., 2013). As a person ages, there have been identifiable decreases within the cognitive abilities and functions of being able to retrieve stored information, working memory, literacy, and other executive functions (Boyle et al., 2013; Hills et al., 2013; Wilson et al., 2013). Particular causes for the decline in cognitive function has been suggested by researchers to be due to deterioration within the areas of the brain associated with cognition caused by the aging process (Wilson et al., 2013). Also decreases in the feelings of well-being, which can further lead to feelings of not having a purpose in life and less use of cognitive functions, has also been associated with cognitive decline (Wilson et al., 2013). The aging process is an unavoidable aspect of life but, physical activity has been found as a way to decrease the risk of cognitive decline and increase cognitive functioning (Bielak, Anstey, Gerstorf, & Luszcz, 2014; Dishman et al., 2006; Kenji et al., 2014; Kleim, 2011; Kravitz, 2011; Marmeleira, 2013). Physical activity contributes towards many benefits for the human body and the effect physical activity has on cognitive function is beneficial for the entire population.

Physical activity and exercise significantly influence cognitive functions and brain health (Dishman et al., 2006; Kenji et al., 2014; Kleim, 2011; Marmeleria, 2013). Physiologically, physical activity and exercise increase the delivery rate of oxygen and vital nutrients to the brain, the rate of blood flow to the brain, the amount of neurotrophins within the brain which support pliability, and the amount of white and grey matter within the brain which can lead to increases in brain volume (Dishman et al., 2006; Kleim, 2011; Marmeleria, 2013). In terms of cognitive function, researchers have found the changes made to the brain from physical activity and exercise increase cognitive performance, enhance learning capabilities, increase the performance of executive functions, and increase the ability to process information cognitively (Dishman et al., 2006; Kleim, 2011; Marmeleria, 2013). In addition, staying physically active and exercising has also been suggested by researchers to increase the ability to process incoming information, reduce the risks for cognitive impairment, reduce the risk of cognitive decline due to the aging process, and reduces the risk for developing a neurological disease which directly affect brain health, such as dementia (Bielak et al., 2014; Kenji et al., 2014; Kleim, 2011). Researchers have determined through numerous studies, individuals leading a sedentary lifestyle were more apt to showing signs of cognitive decline, a decrease in cognitive performance, and an increased risk of developing diseases of the brain such as dementia (Bielak et al., 2014; Kenji et al., 2014; Kleim, 2011; Marmeleria, 2013). Staying physically active and participating in a consistent exercise program are both beneficial ways to stay cognitively incline and when looking at aerobic exercise and resistance exercise specifically, each have exclusive effects on cognition and cognitive function when performed individually or simultaneously.

Effects of Aerobic Exercise on Cognition

Researchers have discovered a correlation between aerobic exercise and cognition through the results of numerous research studies involving human participants (Alderman, Olson, & Mattina, 2014; Davranche, Hall, & McMorris, 2009; Gothe, Pontifex, Hillman, & McAuley, 2013; Kramer et al., 1999; Peiffer, Darby, & Morgan, 2015; Sibley, Etnier, & Masurier, 2006; Yu-Kai et al., 2011). Varies focused approaches have been made by researchers throughout different research studies involving aerobic exercise and cognition each yielding mixed findings (Alderman et al., 2014; Kramer et al., 1999; Peiffer et al., 2015; Gothe et al., 2013; Kamijo et al., 2007; Sibley et al., 2006; Yu-Kai et al., 2011). The various approaches made by different researchers include evaluating the effects of acute bouts of aerobic exercise on cognition versus the effects of chronic aerobic exercise on cognition, the use of different modes of testing in terms of the type of aerobic exercise and cognitive function tests, and the different controlled variables throughout the study (Alderman et al., 2014;Davranche et al., 2009; Gothe et al., 2013; Kramer et al., 1999; Pieffer et al., 2015; Kamijo et al., 2007; Sibley et al., 2006; Yu-

Kai et al., 2011). The research findings concentrating on the effects of aerobic exercise on cognitive function will further be compared and discussed.

Several researchers have discovered a positive relationship between aerobic exercise and cognitive function through a series of research studies primarily focused on the effects of an acute bout of aerobic exercise on tasks directly related to cognitive function (Davranche et al., 2009; Peiffer et al., 2015; Sibley et al., 2006; Yu-Kai et al., 2011). Noteworthy improvements were discovered within the cognitive functions of reaction time, attention, cognitive inhibition, goal processing, response time, and accuracy after an acute bout of aerobic exercise (Davranche et al., 2009; Peiffer et al., 2015, Sibley et al., 2006; Yu-Kai et al., 2011). The improvements noted were discovered from the differences in the results of participant's cognitive function tests before exercise and after exercise and from the differences between exercise group participants and control group participants (Davranche et al., 2009; Peiffer et al., 2015; Sibley et al., 2006; Yu-Kai et al., 2011). The researcher study findings may support a hypothesis of acute aerobic exercise enhancing cognitive function and performance. However, similar research studies have yielded contradicting experimental results and led some researchers to determine an acute bout of aerobic exercise may not have a significant effect on cognitive function and performance (Alderman et al., 2014; Gothe et al., 2013).

Research studies performed by Alderman et al. (2014) and Gothe et al. (2013) focusing on the relationship between an acute bout of aerobic exercise and cognitive function yielded different findings in regards to the relationship between acute aerobic exercise and improvements in cognitive functioning and cognitive performance (Alderman et al., 2014; Gothe et al., 2013). The specific findings from the research studies suggest acute aerobic exercise does not improve the performance of cognitive function tasks, nor does it diminish the performance of cognitive function tasks (Alderman et al., 2014; Gothe et al., 2013). The researcher's findings were determined from the lack of significant differences throughout the different control groups of the studies (Alderman et al., 2014; Gothe et al., 2013). Specifically, within each participant's baseline cognitive function test results and the post-exercise cognitive function results and the similarities between participants who did not participate in aerobic exercise before a cognitive function test and those who did participate in aerobic exercise before a cognitive function test (Alderman et al., 2014; Gothe et al., 2013). The differences in researcher findings focused on the effects of acute aerobic exercise on cognitive function may suggest the need for further research to be performed in order fulfil the gaps within the research surrounding the conflicting topic.

The acute effects of aerobic exercise on cognitive function has been widely examined, yet there are limited studies focused on the chronic effects of aerobic exercise on cognitive function. One research study focused on the effects of a 12-week aerobic exercise program on cognitive function yielded a postive relationship between chronic aerobic exercise and cognitive function (Kamijo et al., 2007). The results of the research study revealed improvements within the rate of cognitive functioning within the participants in the exercise group compared to the participants in the non-exercise group (Kamijo et al., 2007). A similar research study presented by Kramer et al. (1999) had comparable results in improvements within participant's cognitive functions after a 6-month aerobic training program compared to participants who did not participate in a 6-month aerobic training program. Both studies revealed a positive relationship between chronic aerobic exercise and improvements in cognitive function but, as mentioned previously, the number of studies with this focus are limited. The imitation within the research may suggest the need for further studies focusing on the effects of chronic aerobic exercise to be performed by researchers to broaden the relationship between the 2 variables of chronic aerobic exercise and cognitive function.

Overall, researchers have determined a correlation between participating in aerobic exercise and cognitive function (Alderman et al., 2014; Davranche et al., 2009; Gothe et al., 2013; Kamijo et al., 2007; Kramer et al., 1999; Peiffer et al., 2015; Sibley et al., 2006; Yu-Kai et al., 2011). While many researchers have discovered acute aerobic exercise positively effects cognitive functions, other researchers have discovered acute aerobic exercise does not have an influence on cognitive functions, leaving space for further research to be performed in order to increase the knowledge on acute aerobic exercise and cognition (Alderman et al., 2014; Davranche et al., 2009; Gothe et al., 2013; Peiffer et al., 2015; Sibley et al., 2006; Yu-Kai et al., 2011). The lack of research surrounding the topic of the effects the chronic aerobic exercise on cognitive function also suggests the need for further research to be performed as well. In addition, another topic which deserves to be further investigated by researchers is the effects of resistance exercise on cognitive function.

Effects of Resistance Exercise on Cognitive Function

Similarly, to the effects of aerobic exercise on cognitive function, researchers have also discovered a correlation between resistance exercise and cognition (Lachman, Neupert, Bertrand, & Jette, 2006; Yu-Kai & Etnier, 2009). Although the research solely focusing on the effects of resistance training on cognitive function is slim, the postive relationship researchers have found between resistance training and cognitive function suggests the need for continuing research studies (Lachman et al., 2006; Yu-Kai & Etnier, 2009). Researchers have found a direct relationship between the intensity of resistance exercises and improvements in certain cognitive functions (Lachman et al., 2006; Yu-Kai & Etnier, 2009). Research participants who performed resistance exercises at a moderate to high intensity showed improvements in memory, information processing, cognitive inhibition, attention, and executive functions (Lachman et al., 2006; Yu-Kai & Etnier, 2009). The results were discovered from notable differences between the results of participant's pre-exercise cognitive tests and post-exercise cognitive tests and participants who were given different exercise programs (Lachman et al., 2006; Yu-Kai & Etnier, 2009). The findings of a positive relationship between resistance exercise and cognitive function should suggest the need for further research on this topic in order to expand on different findings.

Overall, the distinct findings on the effects of resistance training on cognitive function and the effects of aerobic exercise on cognitive function, as well as the gaps within the research, have influenced the development of further research studies. Researchers have developed research studies where the focus is on the combined effects of aerobic exercise and resistance training on cognitive function (Alves et al., 2012; Han-Byul &Wi-Young, 2015). Although the complex topic has been minimally researched, the researchers who have performed research on the topic have uncovered a promising correlation between the research variables (Alves et al., 2012; Han-Byul & Wi-Young, 2015).

Effects of Aerobic Exercise and Resistance Training on Cognitive Function

Researchers have discovered a positive connection between combined aerobic exercise and resistance training on cognitive function through the findings of different research studies (Alves et al., 2012; Han-Byul & Wi-Young, 2015). Using human participants within each study, notable increases within the performance of cognitive functional tasks, such as selective attention, and overall brain activity after a bout of combined aerobic and resistance exercise were uncovered (Alves et al., 2012; Han-Byul & Wi-Young, 2015). The findings were discovered through the differences within baseline assessments and data and post-exercise assessments and data (Alves et al., 2012; Han-Byul & Wi-Young, 2015). Although studies performed by researchers on the topic of the effects of aerobic exercise and resistance training are slim, the current findings show promising results between the combination of aerobic exercise and resistance exercise on cognitive function (Alves et al., 2012; Han-Byul & Wi-Young, 2015). A postive correlation may further influence other researchers to perform studies on the specific topic in order to contribute additional information within the area of study.

Conclusion

Cognition and the ability to execute cognitive functions are extremely vital to the cognitive tasks of everyday living (Bandura, 1993; Gujord et al., 2014; Kenji et al., 2014). Although the extent of cognition and the ability to execute different cognitive functions tend to develop and increase with age up to a certain point, researchers have determined age and other factors, such a poor health and physical inactivity, can contribute to cognitive decline (Bielak et al., 2014; Boelema et al., 2014; Boyle et al., 2013; Hills et al., 2013; Kenji et al., 2014; Kleim, 2011; Marmeleria, 2013; Pureza et al., 2013; Wilson et al., 2013). Declines in cognition and the ability to execute cognitive functions may preventable through the promising effects physical activity and exercise as demonstrated in the results of numerous research studies (Dishman et al., 2006; Kenji et al., 2014; Kleim, 2011; Marmeleria, 2013; Pescatello et al. (Eds.)., 2013; Staniano et al., 2012; Vuori et al., 2004).

Participation in aerobic exercise and the effects on cognition and cognitive has been a central topic of numerous studies (Alderman et al., 2014; Davranche et al., 2009; Gothe et al., 2013; Kamijo et al., 2007; Kramer et al., 1999; Peiffer et al., 2015, Sibley et al., 2006; Yu-Kai et al., 2011). The majority of the results from the specific research studies have indicated positive correlations between aerobic exercise and cognition, though other researchers have had contradicting results, indicating a need for more research (Alderman et al., 2014; Davranche et al., 2009; Gothe et al., 2013; Kamijo et al., 2007; Kramer et al., 1999; Peiffer et al., 2015, Sibley et al., 2006; Yu-Kai et al., 2011). Participation in resistance exercise, compared to aerobic exercise, has been less extensively researched than aerobic exercise alone. Yet the findings shown a postive correlation between the intensity of the resistance exercise and different cognitive functions, such as information processing and attention (Lachman et al., 2006; Yu-Kai & Etnier, 2009). The findings on the effects of aerobic exercise on cognition and the effects of resistance training on cognition have influenced the development of further research studies which combine the two different forms of exercise on cognitive function (Alves et al., 2012; Han-Byul & Wi-Young, 2015). Although minimally studied, studies which have been performed by researchers have shown a postive correlation between the combination of aerobic exercise and resistance exercise on overall increases in brain activity and cognitive functions, such as selective attention (Alves et al., 2012; Han-Byul & Wi-Young, 2015). There appears to be a postive correlation between the combination of aerobic exercise and resistance exercise on cognition and cognitive functions (Alves et al., 2012; Han-Byul & Wi-Young, 2015). However, a lack of research studies developed within the topic area supports the need for the development of my research study on the effects of acute aerobic exercise and resistance exercise on cognitive function within the college aged population.

Works Cited

Aagaard, P., Simonsen, E., Andersen, J., Magnusson, P., & Dyhre-Poulsen, P. (2003). Increased rate of force development and neural drive of human skeletal muscle following resistance training. (Abstract). *Journal Of Orthopaedic & Sports Physical Therapy*, *33*(5), 287-288

Alderman, B. L., Olson, R. L., & Mattina, D. M. (2014). cognitive function during low-intensity walking: a test of the treadmill workstation. *Journal Of Physical Activity & Health*, *11*(4), 752-758

Alloway, R. G., & Packiam Alloway, T. (2015). The working memory benefits of proprioceptively demanding training: a pilot study. *Perceptual & Motor Skills*, *120*(3), 766-775.

Alves, C. R., Gualano, B., Takao, P. P., Avakian, P., Fernandes, R. M., Morine, D., & Takito, M. Y. (2012). Effects of acute physical exercise on executive functions: a comparison between aerobic and strength exercise. *Journal Of Sport & Exercise Psychology*, *34*(4), 539-549

Baechle, T. R., & Earle, R. W. (Eds.). (2008). *Essentials of Strength Training and Conditioning* (3rd ed.). Human Kinetics.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational psychologist*, *28*(2), 117-148

Bielak, A. M., Gerstorf, D., Anstey, K. J., & Luszcz, M. A. (2014). Longitudinal associations between activity and cognition vary by age, activity type, and cognitive domain.

Psychology And Aging, 29(4), 863-872. doi:10.1037/a0036960

Bird, S. B., Tarpenning, K. M., & Marino, F. E. (2005). Designing resistance training programmes to enhance muscular fitness - A Review of the acute programme variables. *Sports Medicine, 35*(10), 841-851.

Boelema, S. R., Harakeh, Z., Ormel, J., Hartman, C. A., Vollebergh, W. M., & van Zandvoort, M. E. (2014). Executive functioning shows differential maturation from early to late adolescence: Longitudinal findings from a TRAILS study. *Neuropsychology*, *28*(2), 177-187. doi:10.1037/neu0000049

Boyle, P., Schneider, J. A., Segawa, E., Wilson, R. S., Leurgans, S., Bennett, D. A., & Yu, L. (2013). APOE ε4, Alzheimer's disease pathology, cerebrovascular disease, and cognitive change over the years prior to death. Psychology And Aging, 28(4), 1015-1023. doi:10.1037/a0031642

Christoff, K., Ream, J. M., Geddes, L. T., & Gabrieli, J. E. (2003). Evaluating self-generated information: anterior prefrontal contributions to human cognition. *Behavioral Neuroscience*, *117*(6), 1161-1168. doi:10.1037/0735-7044.117.6.1161

Clark, M. A., Sutton, B. G., & Lucett, S. C. (Eds.). (2013). *NASM essentials of personal fitness training* (4th ed.). Burlington, MA: Jones & Bartlett Learning.

Colyer, B. (2013). Thoughts on breathing. *American Swimming*, *2013*(1), 16-17.

Davranche, K., Hall, B., & McMorris, T. (2009). Effect of acute exercise on cognitive control required during an eriksen flanker task. *Journal Of Sport & Exercise Psychology*, *31*(5), 628-639.

Dickhuth, H., Scharhag, J., Röcker, K., & König, D. (2012). FIMS position statement 2012. Cardiovascular adaptations and exercise. *International Sportmed Journal*, *13*(1), 1-7.

Dishman, R. K., Berthoud, H. R., Booth, F. W., Cotman, C. W., Edgerton, V. R., Fleshner, M. R., & ... Zigmond, M. J. (2006). Neurobiology of exercise. Scandinavian Journal Of Medicine & Science In Sports, 16(6), 470.

Dolenc, P., & Petrič, M. (2013). The effects of prolonged physical inactivity induced by bed rest on cognitive functioning in healthy male participants. *Annales Kinesiologiae*, *4*(2), 129-143.

Elliot, R. (2003). Executive functions and their disorders. *British Medical Bulletin, 65*, 49-59.

Figoni, S. F., Kunkel, C. F., Phillips, A. C., & Scremin, M. E. (2012). cardiovascular responses during graded treadmill exercise in men with peripheral arterial disease and intermittent claudication. *Clinical Kinesiology (Online Edition)*, *66*(3), 39-49

Fisher, J., Steele, J., Bruce-Low, S., & Smith, D. (2011). Evidence-based resistance training recommendations. *Medicina Sportiva*, *15*(3), 147-162.

Gobet, F. (2000). Review of The prefrontal cortex. Executive and cognitive functions. *Swiss Journal Of Psychology / Schweizerische Zeitschrift Für Psychologie / Revue Suisse De Psychologie*, *59*(3), 213. doi:10.1024//1421-0185.59.3.213a

Gothe, N., Pontifex, M. B., Hillman, C., & McAuley, E. (2013). The acute effects of yoga on executive function. *Journal Of Physical Activity & Health*, *10*(4), 488-495

Gujord Tangen, G., Engedal, K., Bergland, A., Moger, T. A., & Mengshoel, A. M. (2014). Relationships between balance and cognition in patients with subjective cognitive impairment, mild cognitive impairment, and alzheimer disease. *Physical Therapy*, *94*(8), 1123-1134.

Hagmann, P., Cammoun, L., Gigandet, X., Meuli, R., Honey, C. J., Wedeen, V. J., & Sporns, O. (2008). Mapping the structural core of human cerebral cortex. *PLoS Biology, 6*(7), 1479-1493.

Han-Byul, K., & Wi-Young, S. (2015). Effect of sixteen weeks of combined exercise on body composition, physical fitness and cognitive function in korean children. *South African Journal For Research In Sport, Physical Education & Recreation (SAJR SPER)*, *37*(1), 47-57.

Healy, S. D., & Rowe, C. (2007). A critique of comparative studies of brain size. *Proc. R. Soc., 247*, 453-464. doi:10.1098/rspb.2006.3748

Hills, T. T., Mata, R., Wilke, A., & Samanez-Larkin, G. R. (2013). Mechanisms of age-related decline in memory search across the adult life span. Developmental Psychology, 49(12), 2396-2404. doi:10.1037/a0032272

Hoffman, J. R. (Ed.). (2012). *NSCA's Guide to Program Design*. Human Kinetics.

Hoptman, M. J., & Davidson, R. J. (1994). How and why do the two cerebral hemispheres interact?. *Psychological Bulletin*, *116*(2), 195-219. doi:10.1037/0033-2909.116.2.195

Kamijo, K., Nishihira, Y., Sakai, T., Higashiura, T., Seung-Ryol, K., & Tanaka, K. (2007). Effects of a 12-week walking program on cognitive function in older adults. *Advances In Exercise & Sports Physiology*, *13*(2), 31-39.

Kesse-Guyot, E., Andreeva, V. A., Lassale, C., Hercberg, S., & Galan, P. (2014). Clustering of midlife lifestyle behaviors and subsequent cognitive function: a longitudinal study. *American Journal Of Public Health*, *104*(11), e170-e177.

Kenji, N., Matsuo, E., Takanori, H., Yu, N., Koji, Y., & Shuzo, K. (2014). Physical fitness measures as potential markers of low cognitive function in japanese community-dwelling older adults without apparent cognitive problems. *Journal Of Sports Science & Medicine*, *13*(3), 590-596.

Kleim, J. (2011). Exercise and the Brain: Exciting discoveries underscore how exercise benefits brain health and boosts lifelong learning. *IDEA Fitness Journal*, *8*(3), 74-76.

Kramer, A. F., Hahn, S., Cohen, N. J., Banich, M. T., McAuley, E., Harrison, C. R., . . . Colcombe, A. (1999). Ageing, fitness, and neurocognitive function. *Nature, 400*, 418-419.

Kravitz, L. (2011). From 1998 to 2011: ACSM publishes updated exercise guidelines. *IDEA Fitness Journal*, *8*(9), 18-21

Lachman, M. E., Neupert, S. D., Bertrand, R., & Jette, A. M. (2006). The effects of strength training on memory in older adults. *Journal Of Aging & Physical Activity*, *14*(1), 59.

Marmeleira, J. (2013). An examination of the mechanisms underlying the effects of physical activity on brain and cognition. *European Reviews Of Aging & Physical Activity*, *10*(2), 83-94.

Martini, F., Ober, W. C., & Nath, J. L. (2011). Visual Anatomy & Physiology. San Francisco: Benjamin Cummings.

McArdle, W. D., Katch, F. I., & Katch, V. L. (n.d.). *Exercise physiology: Nutrition, Energy, and Human Performance* (8th ed.). Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins.

Mercado, E. I. (2008). Neural and cognitive plasticity: From maps to minds. *Psychological Bulletin*, *134*(1), 109-137. doi:10.1037/0033-2909.134.1.109

Moore, D. R., Burgomaster, K. A., Schofield, L. M., Gibala, M. J., Sale, D. G., & Phillips, S. M. (2004). Neuromuscular adaptations in human muscle following low intensity resistance training with vascular occlusion. *European Journal of Applied Physiology, 92*, 399-406.

Nadel, L., & Peterson, M. A. (2013). The hippocampus: Part of an interactive posterior representational system spanning perceptual and memorial systems. *Journal Of Experimental Psychology: General*, *142*(4), 1242-1254. doi:10.1037/a0033690

Pearce, P. Z. (2008). Exercise is medicine. *Current Sports Medicine Reports (American College Of Sports Medicine)*, *7*(3), 171-175.

Peiffer, R., Darby, L. A., Fullenkamp, A., & Morgan, A. L. (2015). Effects of acute aerobic exercise on executive function in olderwomen. *Journal Of Sports Science & Medicine*, *14*(3), 574-583

Pescatello, L. S., Arena, R., Riebe, D., & Thompson, P. D. (Eds.). (2013). *ACSM's Guidlines for*

Exercse Testing and Prescription (9th ed.). Lippincott Williams & Wilkins.

Pollmann, S. (2004). Anterior prefrontal cortex contributions to attention control. *Experimental Psychology*, *51*(4), 270-278. doi:10.1027/1618-3169.51.4.270

Pollock, M. L., Gaesser, G. A., Butcher, J. D., Despres, J., Dishman, R. K., Franklin, B. A., & Garber, C. E. (1998). ACSM position stand: the recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Medine & Science in Sports & Exercise, 30*(6), 975-991.

Pontifex, M. B., Hillman, C. H., Fernhall, B., Thompson, K. M., & Valentini, T. A. (2009). The Effect of Acute Aerobic and Resistance Exercise on Working Memory. Medicine & Science In Sports & Exercise, 41(4), 927-934.

Pratt, M., Norris, J., Lobelo, F., Roux, L., & Guijing, W. (2014). The cost of physical inactivity: moving into the 21st century. *British Journal Of Sports Medicine*, *48*(3), 171-173

Pureza, J. R., Gonçalves, H. A., Branco, L., Grassi-Oliveira, R., & Fonseca, R. P. (2013). Executive functions in late childhood: Age differences among groups. *Psychology & Neuroscience*, *6*(1), 79-88. doi:10.3922/j.psns.2013.1.12

Rhodes, R. E., & Dean, R. N. (2009). Understanding physical inactivity: prediction of four sedentary leisure behaviors. *Leisure Sciences*, *31*(2), 124-135

Rosenberg, D. E., Bull, F. C., Marshall, A. L., Sallis, J. F., & Bauman, A. E. (2008). Assessment of sedentary behavior with the international physical activity questionnaire. *Journal Of Physical Activity & Health*, *5*S30-S44.

Shohamy, D., & Turk-Browne, N. B. (2013). Mechanisms for widespread hippocampal involvement in cognition. *Journal Of Experimental Psychology: General*, *142*(4), 1159-1170. doi:10.1037/a0034461

Sibley, B. A., Etnier, J. L., & Le Masurier, G. C. (2006). Effects of an acute bout of exercise on cognitive aspects of stroop performance. *Journal Of Sport & Exercise Psychology*, *28*(3), 285-299

Staiano, A. E., Reeder, B. A., Elliot, S., Joffres, M. R., Pahwa, P., Kirkland, S. A., . . . Katzmarzyk, P. T. (2012). Physical activity level, waist circumfrence, and mortality. *Applied Physiology, Nutrition, and Metabolism, 37*, 1008-1013. Retrieved November 21, 2015.

Steele, J., Fisher, J., McGuff, D., Bruce-Low, S., & Smith, D. (2012). Resistance training to momentary muscular failure improves cardiovascular fitness in humans: a review of acute physiological responses and chronic physiological adaptations. *Journal Of Exercise Physiology Online*, *15*(3), 53-80

Taipale, R. S., Mikkola, J., Nummela, A. T., Sorvisto, J., Nyman, K., Kyröläinen, H., & Häkkinen, K. (2015). Combined strength and endurance session order: differences in force production and oxygen uptake. *International Journal Of Sports Physiology & Performance*, *10*(4), 418-425

Toplak, M. E., West, R. F., & Stanovich, K. E. (2014). Rational thinking and cognitive sophistication: Development, cognitive abilities, and thinking dispositions. *Developmental Psychology*, *50*(4), 1037-1048. doi:10.1037/a0034910

Vuori, I. (2004). Physical inactivity is a cause and physical activity is a remedy for major public health problems. *Kinesiology*, *36*(2), 123-153.

Wallman, K., Plant, L. A., Rakimov, B., & Maiorana, A. J. (2009). The effects of two modes of exercise on aerobic fitness and fat mass in an overweight population. *Research In Sports Medicine*, *17*(3), 156-170.

Willardson, J. F. (2006). A brief review: Factors affecting the length of the rest interval between resistance exercise sets. *Journal of Strength and Conditioning Research, 20*(4)

Wilson, R. S., Boyle, P. A., Segawa, E., Yu, L., Begeny, C. T., Anagnos, S. E., & Bennett, D. A. (2013). The influence of cognitive decline on well-being in old age. Psychology And Aging, 28(2), 304-313. doi:10.1037/a0031196

Wyon, M. (2005). Cardiorespiratory training for dancers. *Journal Of Dance Medicine & Science*, *9*(1), 7-12978-984.

Yu-Kai, C., & Etnier, J. L. (2009). Exploring the dose-response relationship between resistance exercise intensity and cognitive function. *Journal Of Sport & Exercise Psychology*, *31*(5), 640-656

Yu-Kai, C., Chia-Liang, T., Tsung-Min, H., Cheung So, E., Feng-Tzu, C., & Etnier, J. L. (2011). Effects of acute exercise on executive function: a study with a tower of london task. *Journal Of Sport & Exercise Psychology*, *33*(6), 847-865