BODY MASS INDEX, BODY COMPOSITION, AND COGNITIVE FUNCTION IN ADULTS 60 YEARS AND OLDER

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ABSTRACT

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Executive function (EF) is essential for older adults to maintain independence and high quality of life (Lezak, Howieson, & Loring, 2004). Normal cognitive aging is accompanied by decrements in EF (Haug & Eggers, 1991; Raz et al., 1997; Salat et al., 2005). Body fat is thought to mediate this relationship, potentially through the activity of hormones or inflammation. However, the extent of the relationship is not well understood. The aim of this study was to determine whether percentage body fat (PBF) would yield a stronger relationship to EF in older adults than would body mass index (BMI). Participants were adults 60 years and older with no history of mental illness and who were not currently taking medications that could influence the central nervous system. Individuals were screened for mild cognitive impairment using the Montreal Cognitive Assessment. Participants completed the d2 test and modified flanker task to assess EF. In addition, the participants' body composition was estimated through the use of air displacement plethysmography (ADP) and bioelectrical impedance analysis (BIA). Bivariate correlations between PBF and EF test scores, as well as BMI and EF test scores were examined. Multiple and linear regression analyses were calculated to predict the amount of variance in cognitive tests scores as a result of the dependent variables. PBF, using two different methods, and BMI were not significantly correlated to EF. Further research is necessary to clarify the nature of the relationships among body fat, BMI, and cognitive function.
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"True enjoyment comes from activity of the mind and exercise of the body, the two are ever united." – Wilhelm von Humboldt
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CHAPTER I INTRODUCTION

As an individual ages, changes inevitably take place in every body system. Mental processes are no exception. Cognitive function constitutes processing, integration, storage, and retrieval of information related to memory, attention, association, processing speed, perception, and executive function (Smith, Hay, Campbell, & Trollor, 2011; Spirduso, Francis, & MacRae, 2005). Superior cognitive function is key to maintaining a high quality of life as it helps individuals carry out day to day activities. For instance, remembering directions or finding one's way home would not be possible without sound cognition. These cognitive processes are especially important as they relate to the aging population. The segment of population over the age of sixty years all over the world is projected to double from 11 to 22 percent between 2000 and 2050. Further, the number of people who are 80 years of age is expected to quadruple in that time (World Health Organization, 2014). As this segment of the population increases, so will the incidence of people with age related declines in cognition.

Normal cognitive aging is accompanied by changes in brain morphology as well as decrements to cognitive performance (Hubbard & Anderson, 1981; Jernigan et al., 1991; Jernigan et al., 2001; O'Brien et al., 2002; Pakkenberg & Gundersen, 1997). Cerebral atrophy (Pakkenberg & Gundersen, 1997), hyperintensities (lesions) (de Leeuw et al., 2001; O'Brien et al., 2002), decreases in subcortical grey and white matter volume (Hubbard & Andreson, 1997; Gundersen, 1997), and increases in cerebrospinal fluid (Jernigan et al., 1991) have all been cited as common changes with age.

The prefrontal cortex (PFC) of the frontal lobe (FL) has shown to be especially vulnerable to age related decline (Haug & Eggers, 1991; Raz et al., 1997; Salat et al., 2005). Studies have shown that the FL and PFC exhibit greater decreases in connectivity and increases
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in hyperintensities than other areas of the brain (Grieve, Williams, Paul, Clark, & Gordon, 2007; Haug and Eggers, 1991; Jernigan et al., 2001; Prins et al., 2005). The PFC also gives rise to executive function (Luria, 1973). Executive function (EF) is a construct of cognition involved in planning, organizing, coordinating, implementing, and evaluating behaviors related to goal-directed thought, inhibitory control, and attention (Ardila, 2013; Glisky, 2007). EF allows an individual to interact with their environment in a way that is meaningful, where he or she can develop a goal, make a plan of action, monitor progress, and inhibit actions that will hurt progress towards that goal (Gazzaniga, Ivry, & Mangun, 2014).

Owing to the importance of EF in making decisions, substantial research has been devoted to how impairments in EF might be related to obesity. The literature suggests inhibitory control (e.g., excessive food intake) and goal-oriented behavior (e.g., adhering to a diet) can be hindered (Del Parigi et al, 2007; Le et al., 2006) in the case of obesity. Neuroimaging techniques suggest this is related to lower levels of neural activity in the PFC in obese individuals when compared to successful dieters (Del Parigi et al., 2007; Le et al., 2006). While there is promising evidence of a strong relationship between obesity and executive function, this relationship is still uncertain.

There has been considerable literature dedicated to the link between EF and aging. In a similar fashion, more research has focused on the relationships between EF, aging, and obesity. Like the increasing proportion of individuals over 60 years, obesity rates around the world are alarmingly high. The World Health Organization estimates that 1.4 billion adults are obese, a prevalence rate that has doubled since 1980 (The World Health Organization, 2014). Furthermore, recent research suggests that cognitive function, especially EF, in elderly individuals is associated with obesity. The majority of the research in this area uses body mass
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Body Mass Index (BMI) is a person's ratio of weight (kg) to height squared (m²). It is accepted, however, that BMI is not a sensitive measure to changes in body composition as an individual ages [see Baumgartner (1993) for a review]. For instance, fat increase, bone mineral loss, and muscle atrophy (sarcopenia) are common changes with age [see Baumgartner (1993) for review]. Fat is also thought to redistribute throughout the body with age. Abdominal visceral fat increases preferentially over subcutaneous fat (Gallagher et al., 2000; Zamboni et al., 1997). Therefore, increased adiposity with concurrent decreases in skeletal muscle and bone mineral mass can result in an inaccurate categorization of older individuals when measured by BMI.

Historically, BMI has been a convenient, safe, and affordable way to ascertain measurements indicating obesity. Indeed, using BMI has allowed researchers to identify an independent relationship between cognition and obesity. However as research moves forward, it is important to explore potential shortcomings of BMI when estimating obesity in the elderly. Specifically, the current study will examine whether BMI is suitable for studies assessing cognition and aging as mediated by obesity. If not, perhaps a measure of body fatness is a better correlate of this relationship.

Fortunately, advances in technology have made more sensitive measures of body composition convenient for researchers and clinicians. Body composition can be measured with a variety of tools. The gold standard for body composition is hydrostatic weighing (HW) (Brozek, Grande, Anderson, & Keys, 1963). HW is based on Archimedes' principle of water displacement (Brozek et al., 1963). However, HW is often impractical as the test can be strenuous. Resultantly, there are several methods that have been validated against HW that are less strenuous and yield comparable results. Air displacement plethysmography (ADP) is one such method (Vescovi et al., 2001; Yee et al 2001). ADP is based on air displacement instead of
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Water displacement. Body volume can be estimated based on Boyle's Law and the relationship between pressure and volume (i.e., $P_1V_1=P_2V_2$). If the pressure of a chamber is known ($P_{empty}$ and $P_{occupied}$) and the volume inside the empty chamber ($V_1$) is known, then the volume of the person ($V_2$) can be calculated. Keeping in mind that density equals mass per volume (i.e., $D=M/V$), a person's known body mass and volume can be used to calculate his or her body density. Fat mass (FM), fat free mass (FFM), and percent body fat (PBF) can be derived from body density using population specific equations (e.g., Brozek, Siri). ADP has been validated against HW in normal, older, and overweight populations (Vescovi et al., 2001; Yee et al., 2001).

Another validated body composition method is bioelectrical impedance analysis (BIA) (Jackson, Pollock, Graves, & Mahar, 1988; Lukaski, Johnson, Bolonchuk, & Lykken, 1985). Like ADP, BIA is an easy assessment to administer to any population. BIA is based on the principle that water and ions in the body are largely responsible for conducting an electrical current, while adipose tissue resists such current [see Kyle et al., (2004) for a review]. Based on this information, total body water (TBW) can be calculated based on resistance to a current sent through the body and an estimation of body volume (Jackson, Pollock, Graves, & Mahar, 1988). Further, FFM which contains a high percentage of the body's water and electrolytes, is highly correlated with TBW (Hoffer, Meador, & Simpson, 1969; Lukaski, Johnson, Bolonchuk, & Lykken, 1985; Pethig, 1984). Consequently, estimations of FFM, FM, and PBF can be derived from BIA specific equations [see Kyle et al., (2004) for a review]. As a result of these technologies, the relationship between cognition and obesity with age can be examined utilizing a measure of body fat.

An important distinction needs to be made between terms related to body composition. Body composition as defined by Wang, Pierson, and Heymsfield (1992), "includes the amounts
of principal elements (oxygen, carbon, nitrogen, hydrogen, etc.), molecular species (i.e., water, lipid, protein, mineral), fluid, cellular and tissue types (i.e., extracellular fluid, cell mass, adipose tissue mass) in the human body.” Estimates of body composition are often divided into what is known as the two compartment model (Baumgartner, 1993). This model partitions the human body into fat and non-fat, otherwise known as fat-mass (FM) and fat-free mass (FFM) (Baumgartner, 1993). Fat, in this model, is designated as the nonessential adipose tissue used primarily for storage. Fat-free mass, therefore, is everything else in the body (i.e., water, protein, mineral, and glycogen) (Baumgartner, 1993). Measurements of body composition often yield percent body fat (PBF) estimates. BMI, on the other hand, is used as an indicator of body fatness or obesity. BMI does not indicate how much body fat an individual carries. The two ideas are similar, but not synonymous. This distinction is essential to the purpose of the current study.

Significance of the Study

Many hypotheses surrounding the relationship between obesity and cognition assume that excess body fat is the factor used to explain variability in cognition with age. In order to precisely understand this relationship, it seems logical to assess body fat with accurate measurements. Thus far in the literature, this relationship has been investigated using BMI, an indication of obesity, but not a measure of it. This study is original in its effort to specifically determine if body composition is another measure comparable to BMI to identify differences in cognition with age as mediated by body fat.

The potential implications of this study include expanding upon the knowledge base regarding the relationship between body fat and cognition in older adults. It is possible that future research questions cannot be answered using only BMI. For instance, the inquiry as to whether or not there is a threshold amount of body fat in which decreased cognition becomes
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apparent would be better served by using body composition than BMI. This is because BMI is more general in the information it provides, while estimates of PBF can provide more specific information. Future research can also use the results of this study to determine whether or not to use BMI when investigating this relationship. If BMI yields similar results to PBF, then BMI may be suitable for future studies assessing how body fat mediates cognition in elderly individuals. If PBF estimates show a stronger relationship to cognition than BMI, then it is advisable to opt for those measurements in place of BMI.

Purpose of the Study

The purpose of the present study is to determine if a measure of body fatness (determined by ADP and BIA) would yield relationships to executive function test scores in older adults (i.e., ≥60 yrs) similar to an indication of obesity (i.e., BMI).

Hypotheses

It is hypothesized that BMI will be significantly inversely related to executive function (i.e., test scores of total reaction time, congruent and incongruent reaction time, error rate, GZ value, SKL value).

It is hypothesized that PBF (as measured by ADP and BIA) will be significantly inversely related to executive function (i.e., test scores of total reaction time, congruent and incongruent reaction time, error rate, GZ value, SKL value).

Definition of Terms

Cognitive Function: mental processes that allow a person to know something. It can be divided into different domains that include memory, attention, association, processing speed, perception, and executive function (Smith, Hay, Campbell, & Trollor, 2011; Spirduso, Francis, & MacRae, 2005).
Executive Function: high order cognitive function that is involved in behaviors related to goal-directed thought, inhibitory control, and attention (Ardila, 2013; Glisky, 2007). This allows a person to meaningfully interact with their environment where they can develop a goal, make a plan of action, monitor progress, and inhibit actions that will hurt progress toward that goal (Gazzaniga, Ivry, & Mangun, 2014).

Body Mass Index: used to indicate obesity based on the relationship between weight (kg) divided by height (m) squared. For adults, the World Health Organization (WHO) has standardized a set of values that classify underweight (<18.5 kg/m²), normal weight (18.5-24.99 kg/m²), overweight (>25.00 kg/m²) and obese (>30.00 kg/m²) [World Health Organization (WHO), 2014]. These values were adopted by all of the studies and will be used synonymously throughout the paper. For example, overweight is the same as BMI >25 kg/m².

Body Composition: view that the human body is divided into fat and non-fat compartments. Fat mass is defined as energy stored in the form of adipose tissue. Fat-free mass then, is everything except fat and includes water, protein, mineral, and glycogen (Baumgartner, 1993).

d2 test: computerized cognitive assessment of attention and inhibitory aspects of executive function. Scores on the d2 test are reported as error rate, number of letters marked in the test (GZ value), and accuracy of answers (SKL value) (Bates & LeMay, 2004; Brickenkamp, 2002; Budde et al., 2012).

Effect Size: per the recommendation of Field (2005), Pearson correlation coefficients, $r$, were used as a measure of effect size. An $r$ value less than 0.3 is considered a small effect size. An $r$ value between 0.31 and 0.49 is considered a medium effect size, and an $r$ value larger than 0.5 is a large effect size.
**Error Rate**: total number of errors made in the d2 test. This value is standardized by dividing the total number of errors by the number of possible d2s in the test (Budde et al., 2012).

**GZ value**: total number of letters marked in the d2 test regardless of being correct or incorrect selections. This value is standardized by dividing the total number of letters marked by the number of possible d2s in the test (Budde et al., 2012).

**SKL value**: measures attention and accuracy of answers in d2 test. It is calculated by subtracting confusion errors (i.e., letters incorrectly identified as d2) from the amount of accurate answers. This value is standardized by dividing the number of accurate answers by the number of possible d2s in the test (Budde et al., 2012).

**Modified Flanker Task**: computerized cognitive test assessing reaction time, an aspect of executive function. This task measures the amount of time it takes to react to a stimulus of multiple arrows and the direction in which they pointed. The results are reported as total reaction time, congruent reaction time, and incongruent reaction time (Erikson & Erikson, 1974).

**Total Reaction Time**: the mean amount of time it took the participant to respond to each stimulus (Erikson & Erikson, 1974).

**Congruent Reaction Time**: the mean amount of time it took the participant to respond to the congruent situation (i.e., all of stimulus arrows pointing in the same direction) (Erikson & Erikson, 1974).

**Incongruent Reaction Time**: the mean amount of time it took the participant to respond to the incongruent situation (i.e., the stimulus arrows pointing in opposing directions) (Erikson & Erikson, 1974).
CHAPTER II. REVIEW OF THE LITERATURE

In a review of the literature, several studies provide evidence of an inverse relationship between cognitive function and obesity with age. In other words, as obesity increases, cognitive function decreases. This has been shown using a variety of cognitive measures, ages of participants, adiposity measures, covariates, and study designs (e.g., longitudinal or cross-sectional). Studies consistently controlled for age, sex, and education level. All but two studies included a number of additional covariates including physical activity, hypertension, metabolic disorders (e.g., diabetes), blood pressure, health behaviors, (e.g., smoking, drinking status), and psychological status (e.g., depression, anxiety). On the whole, the results were not significantly changed with the inclusion of the extra covariates. In many cases cognitive assessments were used to target short and long term memory, attention, executive function, verbal ability, processing speed, and spatial abilities. It was also very common for general cognitive ability to be assessed with either one test or a composite score from multiple tests. However, the results were often inconsistent with regard to which cognitive abilities were associated with obesity. For example, in a single study executive function may have been significantly associated with obesity, but memory showed no significant relationship (Walther, Birdsill, Glisky, & Ryan, 2010). As a result, this review will include results regarding all aspects of cognitive function, with a focus on EF. However, these mixed findings complicate the interpretation of many studies. Additionally, it calls for more testing in order to clarify the true nature of the relationship between cognition and body composition.

Every study reviewed used BMI to assess obesity. However, some authors included additional body fat or body composition measurements. These included waist circumference (WC), waist hip ratio (WHR), percent body fat (PBF), central fat mass (CFM), abdominal
visceral fat, and abdominal subcutaneous fat. WC, WHR, CFM, abdominal visceral fat, and abdominal subcutaneous fat measurements are intended to supply more specific information about the region of fat distribution (e.g., central vs peripheral) (Lean, Han, & Morrison, 1995; Taylor, Jones, Williams, & Goulding, 2000). The body composition measurements were done using bioelectric impedance (BIA) (Han et al., 2008), computed tomography (CT) (Kanaya et al., 2009; Yoon, Choi, Yu, Ryu, & Park, 2012), and dual-energy x-ray absorptiometry (DXA) (Kanaya et al., 2009). These technologies are used less frequently in the literature, but these studies provide information about PBF that can be helpful to interpret findings of different research regarding body composition.

Cross Sectional Results

Pre-clinical dementia is known to cause weight loss up to 10 years before clinical diagnosis (Johnson, Wilkins, & Morris, 2006; Knopman, 2007). As a result, cross-sectional studies have the potential to inadvertently include these individuals. This could cause results to suggest that lower BMI is related to decreased cognition, because pre-clinical dementia cases would likely score lower on tests of cognitive performance and have lower BMI. Controlling for this possibility is often done by using the Mini-Mental State Exam (MMSE) or the Modified Mini-Mental State Exam (3MS). These are tests that screen for dementia (Folstein, Folstein, & McHugh, 1975; Teng & Chui, 1987). Those individuals below a certain threshold score are considered to be cognitively impaired and are therefore, excluded from the analysis. Regardless of this possibility, cross-sectional studies are a convenient way to obtain information about a population in a short amount of time. As such, these findings are important to understand the relationship between cognition and body composition.
Cross-sectional analyses were included in three of the studies designed to be longitudinal. Sabia, Kivimaki, Shipley, Marmot, and Singh-Manou (2008) assessed BMI and cognition in late life (mean age 61 years). Obesity was associated with lower general cognitive function, memory and executive function test scores. At baseline ages of 32, 42, 52, or 62 years, BMI was significantly correlated with lower cognitive performance in all tests focused on short and long term memory, selective attention, and processing speed (Cournot et al., 2006). Gunstad et al. (2010) showed that increased BMI and WC were significantly related to lower scores in some, but not all, categories of global cognitive function, memory, language, and visuospatial abilities. In contrast, increased BMI and WC were significantly related to better performance in some attention and executive function tests. These results were very similar to those which were found in longitudinal analyses.

The remainder of the studies were designed to be strictly cross-sectional. While much of this research shows an inverse relationship between cognition and BMI, the studies fail to determine if specific aspects of cognition (e.g., EF) are affected more than others.

Gunstad, Paul, Cohen, Tate, Spitznagel, and Gordon (2007) assigned participants to a younger (20-49 yrs) and older (50-82 yrs) cohort and then divided them into normal weight and overweight/obese groups. Following the separation, they were tested on cognitive function. The cognitive domains consisted of multiple tests for estimated intellectual function, attention, and executive function. BMI was significantly inversely associated with scores on all cognitive tests. Yoon, Choi, Yu, Ryu, and Park (2012) also divided participants into a younger group (<70 yrs) and an older group (≥70 yrs). They measured BMI, WC, and abdominal and visceral adipose tissue. Those in the younger group and the top tertile of visceral adipose tissue (>149.0 cm² in men, > 123.7 cm² in women) or having high BMI (≥ 25 kg/m²) were associated with poorer
cognitive performance. There was no relationship between WC or subcutaneous adipose tissue in the younger group. In the older group, high BMI, WC, visceral and subcutaneous adipose tissue were not associated with poor cognitive performance.

Wolf et al. (2007) assessed cognition by eight tests aimed at attention, executive function, visuomotor speed, visual memory, organization, and verbal memory processes. In this study, the authors made a distinction between general obesity (i.e., BMI over 30 kg/m²) and central obesity (i.e., WHR in the top gender-specific quartile). BMI was not related to performance in all cognitive tests. WHR was significantly associated with lower cognitive performance in tests of visual memory and organization. Corley, Gow, Starr, and Deary (2010) reported no relationship between BMI and cognitive scores in processing speed and memory. However, they noted a significant inverse relationship between BMI and verbal ability. Nilsson and Nilsson (2009) found similarly mixed results in their study of participants aged 35-80 years old. BMI and WHR showed no relationship with tests of episodic memory. Men and women with normal BMI and women with normal WHR were however found to perform significantly better on tests of semantic memory. Additionally, all normal WHR participants performed better on visuospatial abilities. There was no relationship between semantic memory and cognition in men and no significant relationship between BMI and visuospatial abilities. Walther, Birdsill, Glisky, and Ryan (2010) found that obesity was significantly related to lower executive function scores in women aged 52 to 92 years. BMI was not significantly related to visuomotor speed or memory in this study.

Two studies found positive relationships between cognitive function and BMI. Kuo et al., 2006 suggest that overweight and obese individuals performed better on reasoning and visuospatial speed of processing tests. There was no relationship found in tests of global
cognition or memory. Elias, Elias, Sullivan, Wolf, and D'Agostino (2003 and 2005) showed different results between males and females. In their cross-sectional studies, men and women aged 55-88 years participated in a battery of eight tests for long term visual memory, verbal learning, visual organization, attention and concentration, abstract reasoning, and concept formation. In the first study, obese men performed significantly poorer in seven out of eight tests. There were no significant differences between obese and normal weight women. In the second study, English as the first language was added to the covariate set. Fewer significant associations remained in men after controlling for the extra covariate. The composite score and two out of eight cognitive tests remained associated with obesity.

Two studies had results that were especially difficult to interpret based on vague reports of covariates by the authors. Yesavage et al. (2014) measured BMI and general cognitive abilities in adults over 50 years. There were four cohorts, with varying characteristics, but the results were not significant. Stanek et al. (2013) found that obesity was significantly related to poor performance in attention and processing speed and motor function. There was not a significant relationship between obesity and poor performance on executive function, language, and memory. The authors of both of these studies made no mention of controlling for age or sex. Stanek et al. (2013) did control for education and other metabolic factors, but Yesavage et al. (2014) did not make such a distinction. Therefore, the interpretation of the results may be different than all other studies that did control for age and sex.

In sum, the findings of the cross sectional studies suggest that obesity, as indicated by BMI, is negatively related to cognitive function. In the majority of studies that directly measured EF, there was an inverse relationship with BMI. Despite this, there are still many inconsistent findings. For example, studies that assessed cognition with multiple tests often found that only
some of the results were statistically significant. It was also suggested that gender had some association to cognition and BMI (i.e., cognition was only associated with BMI in males). One study found that BMI was positively related to attention and EF, but negatively associated with global cognitive function and memory. These inconsistencies could be related to study design. Cross-sectional studies, although limited by the potential for including pre-clinical cases of dementia, are helpful for gathering data from a population in a short amount of time.

Longitudinal Results

Longitudinal studies are able to expand upon the results of cross-sectional studies. Gathering data on the same sample for an extended period of time allows for additional conclusions to be made regarding age-related changes in cognition and body composition as well as identifying the development of disease (e.g., dementia). Still, longitudinal studies can be limited if the follow-up time after baseline measurements is less than ten years. Interpretation of such studies is similar to that of cross-sectional designs. This is by reason of the previously mentioned observation that weight can start to decrease up to ten years before the clinical diagnosis of dementia (Johnson et al., 2006; Knopman, 2007). If follow-up times are less than ten years, then the findings could be affected by the inclusion of these participants. Hence, the follow-up time plays a role in the strength of the study design. Longer follow-up times (i.e., >10 yrs), as opposed to shorter follow-up times (i.e., <10 yrs), can claim more confidently that pre-clinical dementia did not affect the outcome.

The following group of studies had follow-up times less than 10 years. Three studies reported an inverse relationship between BMI and cognition. Cournot et al. (2006) measured cognitive change after five years. Participants were tested by a battery of four cognitive tests focused on short and long term memory, selective attention, and processing speed. BMI was
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significantly correlated to two of the four cognitive tests focused on short term memory and processing speed. Benito-Leon, Mitchell, Hernandez-Gallego, and Bermejo-Pareja (2013) measured BMI in adults over 65 years of age at baseline. The follow up time averaged only 3 years. Being overweight or obese was significantly related to decreased global cognitive function, delayed free recall, immediate logical memory, and premorbid intelligence. There were no significant relationships between BMI and psychomotor speed or verbal fluency. Gunstad, Lhotsky, Wendell, Ferrucci, and Zonderman (2010) found less consistent results when including BMI and WC. Average follow up time was 6 to 9 years. There was no clear difference between results based on WC or BMI. Global cognitive function, attention and executive function, memory, language, and visuospatial abilities were measured with multiple tests. BMI and WC were related to poorer performance on only two tests out of fourteen total. Conversely, increased BMI and WC were significantly related to better performance in some attention and executive function tests.

There were also two studies that report a positive relationship between BMI and cognitive function. Han et al. (2008) studied individuals aged 63-89 over a period of two years. BMI, WHR, WC, and PBF were all measured and observed against the set of tests measuring overall cognitive function. Higher levels of cognitive function were found at follow-up in men who had an increase in BMI, WHR, or WC. Women who had a decrease in BMI, WHR, or WC from normal weight at baseline showed decreased cognitive function over time. It seems that losing weight was detrimental to cognitive performance and increasing weight was beneficial. Also interesting was that there were no significant findings according to PBF. Kanaya et al. (2009) studied individuals aged 70 to 79 years and showed similar results in women only. They measured BMI, WC, PBF, and abdominal visceral and subcutaneous fat. In the seven years
between baseline and follow up, women showed no significant relationship between baseline adiposity measures and change in global cognitive function. However, higher levels of PBF, BMI, WC, and subcutaneous fat were significantly related to decreased cognition in men.

Sturman et al. (2008) was the only longitudinal study to show no relationship at all between cognition and BMI. The authors used a six year follow up period on individuals aged 65 and older. The results originally suggested significance, but became non-significant when individuals with a MMSE score lower than 24 were excluded from the analysis. This clearly reflects the possibility that that individuals with pre-clinical dementia may have affected the sample because weight loss is known to precede the onset of dementia.

Several studies with follow up times greater than 10 years reported similar results. For example, Sabia, Kivimaki, Shipley, Marmot, and Singh-Manoux (2008) assessed BMI during early adulthood (i.e., 25 years) and later in midlife (i.e., mean age of 61 years) and cognition at late midlife. Obesity was associated with lower global cognition scores. However, there were no significant relationships on specific tests of short term verbal memory or executive function. Dahl, Hassing, Fransson, Gatz, Reynolds, and Pedersen (2013) measured cognitive change across 20 years after BMI was initially measured in early (mean age 40 years) and late (mean age 61 years) midlife. Verbal ability, spatial/fluid ability, memory, and perceptual speed were measured using multiple cognitive tests. Results showed that overweight individuals showed decreased cognitive function in all of the cognitive domains. Similarly, Dahl et al. (2009) assessed BMI during midlife (mean age 41.6 years) and cognition in late midlife (over 60 years). Eleven neurocognitive tests were used to assess general cognitive function. BMI in midlife was significantly related to lower general cognitive ability in late life.
Both Hassing, Dahl, Pedersen, and Johansson (2010) and Virta et al. (2013) reported baseline BMI in midlife (50 to 60 yrs), and found similar results when cognitive abilities were assessed 20 to 30 years later. Cognitive tests included long and short term memory, speed, verbal ability, spatial ability, attention and language. BMI in midlife was inversely associated with performance in late life for all cognitive tests (Hassing, Dahl, Pedersen, & Johnasson, 2010). Virta et al. (2013) reported results differently by defining participants as cognitively healthy, mild impairment, or cognitively impaired. Baseline obesity was a significant risk factor for cognitive impairment.

The only longitudinal study with a follow-up time over 10 years that found no relationship between cognition and BMI was done by Knopman, Mosley, Catellier, and Coker (2009). The authors found no relationship between baseline BMI and cognitive decline in verbal ability or short term memory over 14 years in participants between 40 and 70 years old.

Overall, the results from longitudinal studies indicate a negative relationship between cognition and BMI. The same can be said specifically for EF. Interestingly, longitudinal studies with greater than ten years of follow-up times revealed mixed results. Some studies showed no relationship between BMI and any aspect of cognitive function, including EF. Unfortunately, the relationship between obesity and cognition, including EF, is fraught with contradictory findings.

Findings Specific to Percent Body Fat

Only three studies out of the twenty four that were reviewed used a measure of body composition in addition to their use of BMI. Yoon, Choi, Yu, Ryu, and Park (2012), who used CT to assess visceral and subcutaneous adipose tissue, showed similar findings regardless of the measurement type (i.e., BMI or CT scans). Participants younger than 70 years were found to have poorer cognitive function in association with high BMI or large amounts of visceral adipose
tissue. Participants who were 70 years or older, however, showed no association between cognitive function and BMI, visceral, or subcutaneous adipose tissue. Similarly, Kanaya et al. (2009) reported no differences when they used DXA and CT scans. In women, there was no significant relationship found between scores on the Modified Mini-Mental State Test (3MS) and changes in BMI or PBF. On the other hand, men with higher PBF or BMI were shown to have poorer performance on the 3MS. The use of PBF or BMI did not make a difference to the conclusions of these two studies. Unlike the previous two studies, Han et al. (2008) used BIA and found the results were varied. It was suggested that increased BMI protected against cognitive decline. However, there were no significant results when PBF was analyzed.

With only three studies to refer to, it is difficult to draw definitive conclusions. It can be suggested, however, that while convenient, BMI is not the best way to indicate obesity in elderly persons. Body fat measurements may provide a better way to assess the relationship between body fat and cognition in the elderly. While studies using BMI help provide a foundation for this topic, it is clear that additional research is necessary to move knowledge in this field forward.

Possible Neurophysiological Mechanisms

The biological mechanisms responsible for the relationship between body fat and cognitive function are not well understood. There is substantial evidence that body fat influences brain function. In a study by Tikhonoff et al. (2015), it was suggested that body fat mass is the culprit involved in cognitive performance as opposed to simply body mass. This conclusion was drawn from the finding that fat mass was related to memory, attention, and executive function, while body mass was not. An imaging study by Jagust (2007) revealed areas of brain atrophy and changes in white matter in obese individuals that were not observed in non-obese individuals.
These studies, and many others, offer indirect evidence of the role of body fat on cognitive function.

Other studies have reported more direct evidence. One line of research investigates the effects of the inflammatory response on the brain. It is well known that obesity is characterized by chronic systemic inflammation (see Hotamisligil, 2006 for review), which includes increased levels of circulating cytokines (Schmidt et al., 2015). Researchers have found that cytokines (e.g., IL-6, IL-1β) and growth factors (e.g., BDNF) can disturb cellular mechanisms involved in cognition and memory [see Jankowsky & Patterson, (1999) for a review]. Brain derived neurotrophic factor (BDNF), is a well-studied growth factor known to influence physiological processes involved in memory [see Jankowsky & Patterson, (1999) for a review]. Pistell et al. (2010) showed that a high fat diet resulted in increased expression of cytokines as well as decreased expression of brain derived neurotrophic factor (BDNF). Further, the high fat diet was related to poorer performance on behavioral and cognitive tests.

Other lines of evidence focus on the influence of hormones (e.g., leptin, insulin) on the central nervous system. Body fat is related to leptin levels in blood plasma (Maffei et al., 1995). Additionally, the hormone insulin is released after ingesting food in response to elevated blood glucose [see Harvey, (2013) for a review]. Studies have shown leptin and insulin, like BDNF, can be transported into the brain and influence synaptic activity important for memory [see Bliss & Collingridge, (1993) and Harvey, (2013) for a review]. It is unclear how different hormones work together or communicate in this cascade of events, and there are many unanswered questions in regard to this relationship. However, these studies make it apparent that body fat can independently influence the brain.
CHAPTER III METHODS

Participants

The participants were individuals 60 years of age and older recruited from the city of Bowling Green and close surrounding areas. Due to the importance of cognition in this study, individuals were excluded based on the following criteria: 1) having a history of mental illness (e.g., depression, bipolar disorder), 2) having a history of a neurological condition (e.g., dementia, Parkinson's disease), 3) currently taking medications that act on the central nervous system (e.g., antidepressants, antiepileptic medications), 4) having a history of substance abuse (i.e., having had to go to a treatment program for substance use), and 5) showing signs of mild cognitive impairment (i.e., achieve less than minimum score of 24 on Montreal Cognitive Assessment). The presence of any of these conditions was assessed based on a self-reported medical history questionnaire and completion of the Montreal Cognitive Assessment. Also, to comply with the regulations of using the BOD POD, individuals could not be claustrophobic and could not have a body mass greater than 500 pounds. Finally, participants with contraindications rendering it unsafe to complete the 6 minute walk test (i.e., unstable angina or myocardial infarction during the previous month, resting HR over 120 bpm, systolic BP over 180 mmHg, or diastolic BP over 100 mmHg) at the laboratory were excluded.

Equipment

The Exercise Physiology Laboratory Medical History Questionnaire from Bowling Green State University was used to ascertain pertinent medical information. A sphygmomanometer was used for assessing participants' blood pressure. The Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005) was used to assess mild cognitive impairment. It is a paper and pencil test. A computer was used for the d2 test and modified flanker task. Two different methods, air
displacement plethysmography (ADP) and bioelectrical impedance analysis (BIA), were used to assess body composition. For measurements using ADP, the BOD POD (COSMED, Rome, Italy) was used. The InBody 230 (InBody Co., Seoul, Korea) was used to estimate body composition through BIA. All of the equipment was used according to the manufacturers’ recommendations. BMI was calculated based on height and weight measurements taken from a stadiometer and the BOD POD digital scale respectively. The 6 minute walk test required gymnasium space, a standardized worksheet for participant information, chair, and a stopwatch.

Procedure

The participants were asked to come into the Exercise Physiology Lab at Bowling Green State University one time for this study. Upon arrival, the participants were provided information about the study, encouraged to ask any questions, and asked to sign an informed consent form. The study was approved by the Human Subjects Review Board at Bowling Green State University.

As previously mentioned, the participants were asked to fill out a medical history questionnaire provided by the researcher in order to determine if they were suitable for inclusion into this study. This was completed in about 5 to 10 minutes.

While the participant was seated, the researcher obtained resting heart rate (HR) and blood pressure (BP) values. According to the American Thoracic Society (2002), individuals with unstable angina or myocardial infarction during the previous month should not participate in the 6 minute walk test. Additionally, participants with a resting HR over 120 bpm, systolic BP over 180 mmHg, or diastolic BP over 100 mmHg should obtain permission from a physician prior to performing the test. Due to this recommendation, individuals with these
contraindications were to be excluded from the study. However, there were no participants excluded from the study based on these recommendations.

The final step in determining if an individual was eligible for this study was to complete the Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005). This test is intended to identify individuals with mild cognitive impairment (MCI), which often progresses into dementia (Peterson et al., 2005). The MoCA includes questions aimed at short term memory recall, visuospatial abilities, EF, attention, concentration, working memory, language, and orientation. The test is scored out of 30 points and took approximately 10 minutes to complete. A score of 26 or above is considered normal, while any score lower is suggestive of MCI. In the original validation study, MoCA detected Alzheimer’s disease (AD) and MCI with 100% and 90% sensitivity respectively (Nasreddine et al., 2005). In contrast, the widely used dementia screening tool known as the Mini-Mental State Exam (MMSE) (Folstein, Folstein, & McHugh, 1975), detected mild AD with 87% sensitivity, and only detected MCI correctly 18% of the time. Further validation studies reported similar findings especially when scores at or above 24 were considered normal (Dong et al., 2012; Luis, Keegan, & Mullan, 2009; Zadikoff et al., 2007).

The medical history questionnaire and MoCA were evaluated immediately upon completion. Therefore, the researcher was able to determine if the participant was eligible to continue with the study. If the participant was not eligible to continue, the researcher informed the individual that they were unable to participate in the study. However, the researcher extended the opportunity to carry out body fat estimation for the participant.

The participants were asked to abstain from food, drink, and exercise for four hours prior to completing body fat estimates. A stadiometer was used to measure height, as it was necessary for BIA and BOD POD measurements. BOD POD measurements were taken first. For accurate
results, participants were asked to wear form fitting clothing (i.e., swimsuit or single layer compression shorts and bras). Additionally, a cap was provided to cover the participant's head and all jewelry was removed. Following BOD POD calibration, body mass was measured with the BOD POD digital scale. The height and body mass from the BOD POD was used to calculate BMI. The participant was asked to sit quietly inside the BOD POD chamber. The chamber door was closed and two or three measurements, each lasting approximately 45 seconds, were taken with the participant inside. The participants were informed that if they were uncomfortable, they could signal for the test to be stopped at any point through the BOD POD window. The participant's BMI was also calculated using the measurements of height and weight.

Following BOD POD measurements, BIA measurements were completed. BIA requires that the user stand for at least 5 minutes prior to measurements. This time was passed almost entirely by discussing the BOD POD print-out and the procedure for BIA. In this study, the InBody 230 (InBody Co., Seoul, Korea) was used. This device required the participant to stand, barefoot, on electrodes and hold onto a bar with electrodes with both hands to complete the electrical circuit. This test was completed in about one minute.

After completion of body composition measurements, the participants were allowed to change clothes and given a small break (about 5 to 10 min) and provided water, juice, and granola bars. This was done to avoid any effects associated with having to fast prior to the body composition measurements, as well as to make certain the participants were ready to take the cognitive tests.

Next, attention and inhibitory aspects of EF were assessed using two computerized tests, the d2 and the modified flanker task. The d2 is a measurement of sustained and selective attention, a component of behavioral inhibition, and consequently EF. (Bates & LeMay, 2004,
Brickenkamp, 2002; Budde et al., 2012). In this test, there were fourteen lines of 47 randomly assorted letters (i.e., “p” and “d”). The letters have 1 to 4 dashes above or below each letter. The participant was instructed to click on, via a computer mouse, only the letter “d” with two dashes above or below it (hence the name d2 test). The participant was shown one line at a time for 20 seconds before moving on to the next line. Thus, attention is measured based on error rate (ER), number of letters marked in the test (GZ value), and accuracy of answers (SKL value) (Budde et al., 2012). The total time for this test was 5 minutes. Bates and LeMay (2004) and Kamijo et al. (2009) showed practice with 3 or 4 lines of the d2 test was sufficient to significantly reduce the effects of learning. As a result, the participants in this study were required 4 practice trials of the d2 test prior to actual testing.

The participants also completed the modified flanker task, a measure of reaction time (Erikson & Erikson, 1974). In this test, the participant was presented with five arrows on a computer screen (e.g., >>>>>). The arrow in the middle was known as the target stimulus. The arrows surrounding the target stimulus on each side were known as “noise” stimuli. The noise stimuli can be congruent or incongruent. In the congruent condition, the arrows point in the same direction as the target arrow (e.g., <<<<<<). In the incongruent condition, the arrows can point in the same or different directions as the target arrow (e.g., >>> < <). The participant used the “control” keys on a keyboard to indicate which direction the target arrow was pointing. When the target arrow pointed right, the participant was instructed to hit the right “control” key. Similarly, when the target arrow pointed left, the participant was instructed to hit the left “control” key. The incongruent condition necessitated that the participant process interfering information. As a result, reaction time is slowed (Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999). The test took approximately 8.5 minutes to complete; 80 situations were presented (40 congruent and 40
Performance was measured based on total reaction time (TRT), reaction time for the congruent condition (CRT), and reaction time for the incongruent condition (IRT). Thus, a smaller value indicated better performance on this cognitive test. Similar to the d2, participants were required 32 pre-testing situations to minimize the effects of learning.

The order of the two cognitive tests was randomized to reduce any possible order effects. For the first participant, this was done by randomly selecting which test was completed first. Every participant thereafter alternated the order in which they took the cognitive tests.

Finally, participants completed the 6 minute walk test (6MWT). As the name would suggest, participants were asked to walk as far as possible in 6 minutes. A standardized walking course with cones to designate turning points was used. The number of laps completed was counted to determine the final distance covered by each participant. This test was used to predict aerobic capacity. Studies have shown that individuals with higher functional capacity, particularly aerobic capacity, have higher levels of cognitive function with age (Laurin, Verreault, Lindsay, MacPherson, & Rockwood, 2001; Weuve et al., 2004; Barnes, Yaffe, Satariano, & Tager, 2003). Further, the 6MWT has been independently associated with cognitive function (Baldasseroni et al., 2010). As such, the 6MWT scores in this study potentially were used to control for differences in cognitive function not due to body fat.

**Statistical Analyses**

Means and standard deviations were calculated for age, height, body mass, BMI, PBF, distance walked in the 6MWT, and resting blood pressure. Frequencies were calculated for education, gender, the use of hypertensive medication, socioeconomic status, smoking status, type II diabetes status, and history of heart attack or chest pain. The primary analysis examined the bivariate associations between: 1) BMI and cognitive test scores, and 2) PBF and cognitive...
test scores. Partial correlations were examined and reported for each of the aforementioned associations controlling for age, sex, education, distance walked in the 6MWT, and hypertension/use of hypertensive medications. The level of significance was set \textit{a priori} \((p<0.05)\). Statistical significance was determined using the \(p\) value. However, effect size was also established in order to evaluate the magnitude of the observed effect in the absence of statistical significance. This allowed the researcher to note any findings that were of importance even when not statistically significant. Based on recommendations by Field (2005), Pearson correlation coefficients, \(r\), were used as a measure of effect size. An \(r\) value less than 0.3 is considered a small effect size. An \(r\) value between 0.31 and 0.49 is considered a medium effect size, and an \(r\) value larger than 0.5 is a large effect size. The coefficient of determination, \(R^2\), was used to determine the variance in the dependent variable as explained by the independent variable. Multiple and linear regression models were calculated to predict the amount of variance in cognitive scores as a result of BMI or PBF. In the multiple linear regression analyses, \(R\) was used to represent the correlation between the independent and dependent variables in multiple linear regression analyses. The statistics were analyzed using \textit{IBM SPSS Statistics} v. 23.0 (IBM Corp., Armonk, NY).
CHAPTER IV. RESULTS

Participant Characteristics

Demographic data for the participants is reported in Table 1. There were 10 total participants (N=3 males; N=7 females), all of which were Caucasian. Of those participants, 20 percent (N=2) were taking hypertensive medication, 10 percent (N=1) had previously experienced a heart attack or chest pain, however, no participants had been diagnosed with Type II Diabetes or were current smokers. Eighty percent (N=8) of the participants had a bachelor’s degree or higher. This was determined by the highest level of education an individual had attained (i.e., 8th grade, high school, some college, vocational training, associate’s degree, bachelor’s degree, master’s degree, doctoral degree, professional degree). For males the average BMI was 30.0 ± 5.3 kg/m², and for females it was 22.7 ± 3.3 kg/m². In males, the mean PBF BIA was 33.7 ± 9.0%, while the average PBF ADP was 31.3 ± 6.3%. Females had an average PBF BIA of 31.9 ± 6.6%, and an average PBF ADP of 33.0 ± 7.3%. Means and standard deviations for the results of the cognitive tasks are presented in Tables 2 and 3.

Table 1

Descriptive Characteristics of Participants (N=10)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>72.0 ± 5.9</td>
<td>61-81</td>
</tr>
<tr>
<td>Body Mass (kg)</td>
<td>66.2 ± 16.2</td>
<td>42.6-95.9</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.9 ± 5.1</td>
<td>18.4-36.1</td>
</tr>
<tr>
<td>PBF ADP (%)</td>
<td>32.5 ± 6.7</td>
<td>23.2-44.0</td>
</tr>
<tr>
<td>PBF BIA (%)</td>
<td>26.4 ± 1.8</td>
<td>22.3-28.0</td>
</tr>
<tr>
<td>6MWT dist (ft)</td>
<td>1918 ± 158</td>
<td>1671.0-2184.0</td>
</tr>
<tr>
<td>RPE 3</td>
<td>9 ± 6</td>
<td>6-13</td>
</tr>
<tr>
<td>RPE 6</td>
<td>9 ± 3</td>
<td>6-14</td>
</tr>
<tr>
<td>Systolic BP (mmHg)</td>
<td>124 ± 10</td>
<td>108-142</td>
</tr>
<tr>
<td>Diastolic BP (mmHg)</td>
<td>70 ± 10</td>
<td>56-84</td>
</tr>
</tbody>
</table>

Note: ADP = air displacement plethysmography; BIA= bioelectrical impedance analysis; PBF= percent body fat; 6MWT= 6 minute walk test; RPE 3= rate of perceived exertion at 3 minutes; RPE 6 = rate of perceived exertion at 6 minutes; BP= blood pressure

Table 2
**Mean and Standard Deviations for Error Rate, GZ value, and SKL value in d2 Test (N=10)**

<table>
<thead>
<tr>
<th>d2 Test</th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error Rate (accuracy)</td>
<td>0.372 ± 0.163</td>
<td>0.12 - 0.16</td>
</tr>
<tr>
<td>GZ Value (total letters marked)</td>
<td>0.678 ± 0.170</td>
<td>0.43 - 0.96</td>
</tr>
<tr>
<td>SKL Value (accuracy)</td>
<td>0.287 ± 0.327</td>
<td>0.24 - 0.80</td>
</tr>
</tbody>
</table>

**Table 3**

**Mean and Standard Deviations for Total Reaction Time, Incongruent Reaction Time, and Congruent Reaction Time in Modified Flanker Task (N=10)**

<table>
<thead>
<tr>
<th>MF Task</th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Reaction Time (ms)</td>
<td>706.8 ± 99.2</td>
<td>581.1-886.9</td>
</tr>
<tr>
<td>Incongruent Reaction Time (ms)</td>
<td>729.4 ± 107.6</td>
<td>597.1-949.1</td>
</tr>
<tr>
<td>Congruent Reaction Time (ms)</td>
<td>697.3 ± 100.3</td>
<td>574.5-890.5</td>
</tr>
</tbody>
</table>

**Correlations**

There were no statistically significant correlations between PBF and measures of attention (i.e., ER, GZ, SKL value) or reaction time (i.e., TRT, IRT, CRT). The \( r \) values between PBF and cognitive function indicated small, as well as medium effect sizes. The medium effect sizes were only found between PBF and some measures of reaction time, not attention. The correlation coefficients were positive, which indicates that an increase in body fat was related to slower reaction time.

No statistically significant associations were found between BMI and measures of attention or reaction time. All correlation coefficients between BMI and cognitive outcomes had small effect sizes. The values are shown in Table 4.
Table 4

Pearson Correlations ($r$ value) between $d_2$ Test and Modified Flanker Task Results, PBF, and BMI

<table>
<thead>
<tr>
<th></th>
<th>$d_2$ Test</th>
<th></th>
<th>MF Task</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ER</td>
<td>GZ</td>
<td>SKL</td>
<td>TRT</td>
<td>IRT</td>
<td>CRT</td>
</tr>
<tr>
<td>N=10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBF</td>
<td>Correlation</td>
<td>-0.092</td>
<td>-0.155</td>
<td>0.01</td>
<td>0.361</td>
<td>0.258</td>
</tr>
<tr>
<td></td>
<td>$R^2$</td>
<td>0.009</td>
<td>0.024</td>
<td>0.0001</td>
<td>0.13</td>
<td>0.067</td>
</tr>
<tr>
<td></td>
<td>Sig</td>
<td>0.801</td>
<td>0.67</td>
<td>0.979</td>
<td>0.306</td>
<td>0.472</td>
</tr>
<tr>
<td>BIA</td>
<td>Correlation</td>
<td>-0.195</td>
<td>0.117</td>
<td>0.173</td>
<td>0.335</td>
<td>0.311</td>
</tr>
<tr>
<td></td>
<td>$R^2$</td>
<td>0.038</td>
<td>0.014</td>
<td>0.03</td>
<td>0.112</td>
<td>0.097</td>
</tr>
<tr>
<td></td>
<td>Sig</td>
<td>0.589</td>
<td>0.748</td>
<td>0.633</td>
<td>0.343</td>
<td>0.382</td>
</tr>
<tr>
<td>PBF</td>
<td>Correlation</td>
<td>-0.106</td>
<td>0.059</td>
<td>0.093</td>
<td>0.054</td>
<td>-0.077</td>
</tr>
<tr>
<td>ADP</td>
<td>$R^2$</td>
<td>0.011</td>
<td>0.004</td>
<td>0.009</td>
<td>0.003</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>Sig</td>
<td>0.77</td>
<td>0.872</td>
<td>0.798</td>
<td>0.882</td>
<td>0.832</td>
</tr>
</tbody>
</table>

Note: PBF= percent body fat, BIA= bioelectrical impedance analysis; ER= error rate, total number of errors made in $d_2$ test; GZ value= total number of letters marked in $d_2$ test; SKL value= measure of accuracy/attention, calculated by subtracting confusion errors from the amount of accurate answers; TRT= total reaction time; IRT= incongruent reaction time; CRT= congruent reaction time; ER, GZ, and SKL values were all standardized by dividing by the total number of $d_2$s presented in each test; TRT, IRT, and CRT values are all presented as the mean of the reaction time

Partial correlations controlling for age, sex, education, distance walked in the 6MWT, and hypertension or use of hypertensive medications were calculated between the cognitive tests results, PBF, and BMI. Smoking status and type II diabetes were not controlled for because none of the participants were current smokers or were diagnosed with type II diabetes. The results are reported in Table 5.

There was one statistically significant correlation found between PBF BIA and CRT ($r=0.944, p=0.016$) after controlling for the additional variables. There were also large effect sizes found between PBF BIA and the other two measures of reaction time, as well as ER.
One statistically significant partial correlation was found between PBF ADP and ER ($r=-0.908, p=0.033$). All of the other outcomes of executive function showed large effect sizes with PBF ADP, except IRT. In the presence of higher PBF, both BIA and ADP, the correlation coefficients were indicative of better performance on the attention tasks. However, PBF was related to compromised reaction time.

There were no statistically significant associations between BMI and measures of attention or reaction time after controlling for the additional variables. BMI had one large effect size in relation to IRT. Higher BMI was beneficial to reaction time.

Table 5

Partial Correlations (r value) between d2 Test and Modified Flanker Task Results, PBF, and BMI

<table>
<thead>
<tr>
<th></th>
<th>N=10</th>
<th>d2 Test</th>
<th>MF Task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ER</td>
<td>GZ</td>
</tr>
<tr>
<td>PBF BIA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td>-0.512</td>
<td>0.315</td>
<td>0.452</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.262</td>
<td>0.099</td>
<td>0.204</td>
</tr>
<tr>
<td>Sig.</td>
<td>0.378</td>
<td>0.605</td>
<td>0.445</td>
</tr>
<tr>
<td>PBF ADP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td>-0.908</td>
<td>0.795</td>
<td>0.878</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.824</td>
<td>0.632</td>
<td>0.771</td>
</tr>
<tr>
<td>Sig.</td>
<td>0.333*</td>
<td>0.108</td>
<td>0.05</td>
</tr>
<tr>
<td>BMI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td>-0.301</td>
<td>0.282</td>
<td>0.291</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.091</td>
<td>0.08</td>
<td>0.085</td>
</tr>
<tr>
<td>Sig.</td>
<td>0.623</td>
<td>0.646</td>
<td>0.635</td>
</tr>
</tbody>
</table>

Note: PBF= percent body fat; BIA= bioelectrical impedance analysis; ER= error rate; TRT= total reaction time; IRT= incongruent reaction time; CRT= congruent reaction time; Partial correlations controlled for age, sex, education, distance walked in 6MWT, blood pressure, and use of hypertensive medications; *p<0.05

Regarding the other variables measured in this study, education and rate of perceived exertion (RPE) during the 6MWT were the only variables significantly related to any outcome of cognitive function. Education was negatively associated to reaction time and RPE was positively
associated with reaction time. Although, neither variable showed an association with attention. Faster reaction time was related to higher levels of education and lower perceived exertion during the 6MWT. The results are shown in Table 6.
### Table 6

**Pearson Correlations (r value) between d2 Test and Modified Flanker Task Results, and Additional Variables**

<table>
<thead>
<tr>
<th></th>
<th>N=10</th>
<th>Education</th>
<th>Age</th>
<th>Gender</th>
<th>SES</th>
<th>HR</th>
<th>SBP</th>
<th>DBP</th>
<th>6MWT dist</th>
<th>RPE 3</th>
<th>RPE 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>ER</td>
<td></td>
<td>Correlation</td>
<td>-0.148</td>
<td>0.544</td>
<td>-0.38</td>
<td>-0.059</td>
<td>0.111</td>
<td>0.359</td>
<td>-0.368</td>
<td>-0.07</td>
<td>0.315</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R²</td>
<td>0.022</td>
<td>0.296</td>
<td>0.144</td>
<td>0.003</td>
<td>0.012</td>
<td>0.129</td>
<td>0.135</td>
<td>0.005</td>
<td>0.099</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sig</td>
<td>0.684</td>
<td>0.104</td>
<td>0.278</td>
<td>0.872</td>
<td>0.76</td>
<td>0.309</td>
<td>0.296</td>
<td>0.848</td>
<td>0.376</td>
</tr>
<tr>
<td>GZ</td>
<td></td>
<td>Correlation</td>
<td>0.299</td>
<td>-0.522</td>
<td>0.38</td>
<td>0.206</td>
<td>-0.096</td>
<td>-0.481</td>
<td>0.254</td>
<td>0.288</td>
<td>-0.291</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R²</td>
<td>0.089</td>
<td>0.272</td>
<td>0.144</td>
<td>0.042</td>
<td>0.009</td>
<td>0.231</td>
<td>0.065</td>
<td>0.082</td>
<td>0.085</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sig</td>
<td>0.401</td>
<td>0.122</td>
<td>0.278</td>
<td>0.568</td>
<td>0.791</td>
<td>0.159</td>
<td>0.479</td>
<td>0.42</td>
<td>0.414</td>
</tr>
<tr>
<td>SKL</td>
<td></td>
<td>Correlation</td>
<td>0.206</td>
<td>-0.549</td>
<td>0.384</td>
<td>0.10</td>
<td>-0.113</td>
<td>-0.396</td>
<td>0.346</td>
<td>0.14</td>
<td>-0.314</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R²</td>
<td>0.042</td>
<td>0.301</td>
<td>0.147</td>
<td>0.01</td>
<td>0.013</td>
<td>0.157</td>
<td>0.12</td>
<td>0.02</td>
<td>0.099</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sig</td>
<td>0.569</td>
<td>0.1</td>
<td>0.273</td>
<td>0.783</td>
<td>0.756</td>
<td>0.257</td>
<td>0.327</td>
<td>0.699</td>
<td>0.377</td>
</tr>
<tr>
<td>TRT</td>
<td></td>
<td>Correlation</td>
<td>-0.719</td>
<td>0.172</td>
<td>0.067</td>
<td>-0.232</td>
<td>0.248</td>
<td>-0.304</td>
<td>-0.275</td>
<td>0.159</td>
<td>0.648</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R²</td>
<td>0.517</td>
<td>0.03</td>
<td>0.004</td>
<td>0.054</td>
<td>0.062</td>
<td>0.092</td>
<td>0.076</td>
<td>0.025</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sig</td>
<td>0.019*</td>
<td>0.634</td>
<td>0.854</td>
<td>0.52</td>
<td>0.49</td>
<td>0.394</td>
<td>0.422</td>
<td>0.66</td>
<td>0.043*</td>
</tr>
<tr>
<td>IRT</td>
<td></td>
<td>Correlation</td>
<td>-0.606</td>
<td>0.151</td>
<td>0.138</td>
<td>-0.486</td>
<td>0.271</td>
<td>-0.188</td>
<td>-0.097</td>
<td>0.077</td>
<td>0.707</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R²</td>
<td>0.367</td>
<td>0.033</td>
<td>0.019</td>
<td>0.236</td>
<td>0.073</td>
<td>0.035</td>
<td>0.009</td>
<td>0.006</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sig</td>
<td>0.063</td>
<td>0.678</td>
<td>0.703</td>
<td>0.154</td>
<td>0.449</td>
<td>0.603</td>
<td>0.79</td>
<td>0.832</td>
<td>0.022*</td>
</tr>
<tr>
<td>CRT</td>
<td></td>
<td>Correlation</td>
<td>-0.731</td>
<td>0.173</td>
<td>0.024</td>
<td>-0.099</td>
<td>0.22</td>
<td>-0.349</td>
<td>-0.35</td>
<td>0.194</td>
<td>0.582</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R²</td>
<td>0.534</td>
<td>0.03</td>
<td>0.0006</td>
<td>0.01</td>
<td>0.048</td>
<td>0.122</td>
<td>0.123</td>
<td>0.038</td>
<td>0.339</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sig</td>
<td>0.016*</td>
<td>0.632</td>
<td>0.948</td>
<td>0.786</td>
<td>0.541</td>
<td>0.322</td>
<td>0.032</td>
<td>0.591</td>
<td>0.078</td>
</tr>
</tbody>
</table>

*Note: ER= error rate; TRT= total reaction time; IRT= incongruent reaction time; CRT= congruent reaction time; SES = socioeconomic status; HR= heart rate; SBP= systolic blood pressure; DBP = diastolic blood pressure; 6MWT dist = 6 minute walk test distance; RPE 3= rate of perceived exertion at 3 minutes; RPE 6= rate of perceived exertion at 6 minutes; ER, GZ, and SKL values were all standardized by dividing by the total number of d2s presented in each test; TRT, IRT, and CRT values are all presented as the mean of the reaction time; *p<0.05
Simple Linear Regression Analyses

In order to investigate the relative contribution of PBF and BMI on cognitive outcomes, linear regression models were created. The variables that were analyzed were based on the correlations. Although none of the relationships were statistically significant, correlations with larger effect sizes (e.g., PBF BIA and CRT) were used to better understand the nature of this relationship. In a simple linear regression, with CRT as the outcome variable and PBF BIA as the predictor variable, PBF BIA accounted for 15.8% of the variance in CRT ($F_{1,8} = 1.506, p = 0.255$). PBF ADP accounted for slightly less at 10.3% ($F_{1,8} = 0.919, p = 0.366$), while BMI only predicted 1.2% of the variance ($F_{1,8} = 0.101, p = 0.759$). A simple linear regression model was also created with education as the predictor variable. This was because education had a significant correlation with two outcomes of the modified flanker task. Education predicted 53.4% of the variance in CRT ($F_{1,8} = 9.172, p = 0.016$) and 51.7% of the variance in TRT ($F_{1,8} = 8.565, p = 0.019$).

Multiple Linear Regression Analyses

Multiple linear regression models were also calculated adjusting for the influence of age, gender, education, distance walked on 6MWT, and hypertension/use of hypertensive medications. The outcome variable chosen to analyze was ER, due to its significant association with PBF ADP.

The predictor variables PBF ADP, age, gender, education, distance walked, hypertension/use of hypertensive medications accounted for 91% of the variance in ER ($F_{6,3} = 5.411, p = 0.097$), though this model was not statistically significant. Based on the semi-partial correlations in the model, the unique contribution of each predictor can be determined. PBF ADP was the only significant predictor ($R = -0.631, p = 0.033$). In this model, increased PBF tended towards better scores related to ER.
The multiple linear regression model with PBF BIA in addition to the other control variables accounted for 64% of the variance in ER ($F_{6,3} = 0.905, p = 0.583$). This model was not significant and neither were any of the predictor variables based on the semi-partial correlations.

Using BMI as a predictor variable accounted for 56% of the variance in ER ($F_{6,3} = 0.640, p = 0.707$), along with the other predictor variables. Again, the model was not statistically significant. There were no significant predictor variables based on the semi-partial correlations either.
CHAPTER V. DISCUSSION

There were no statistically significant correlations found between PBF BIA and scores on executive function tests. However, after controlling for additional variables there was a significant association between PBF BIA and CRT ($r=0.944$, $p=0.016$). In addition, although not statistically significant, there were large effect sizes found between TRT, IRT, and ER. This suggests that although not statistically significant, a practically significant amount of variance in the cognitive test scores can be explained by PBF BIA. This is also evidenced by the finding that PBF BIA accounted for 85% of the variance in TRT ($r=0.847$, $p=0.070$) in the modified flanker task.

No statistically significant associations were found between PBF ADP and executive function outcomes. Again, however, there was a significant association between PBF ADP and ER ($r=-0.908$, $p=0.033$) after controlling for age, gender, education, distance walked in the 6MWT, and hypertension/hypertensive medications. Large effect sizes were found in all but one of the other cognitive outcomes. On the whole, in this study higher levels of body fat were protective of attention, but detrimental to reaction time.

Inconclusive results such as the ones noted in this study have been common in previous studies. Differential influences of body fat on cognition relative to age could be implicated as a reason for such outcomes. For example, Yoon et al. (2009) found poor cognitive performance related to increased visceral fat in participants 70 years and younger, and no significant associations in the participants older than 70 years. Similarly, Smith, Hay, Campbell, and Trollor (2011) cited that obese individuals younger than 72 years were likely to have cognitive deficits, while those who were 72 years and older seem to benefit from additional weight. While being overweight or obese is a risk factor for many diseases in younger adults, it could be concluded
that overweight or obesity is a protective factor in older populations [see Chang, Beason, Hunleth, & Colditz (2012) for a review]. Therefore, older adults who were overweight or obese had a smaller risk of morbidity or mortality. According to these cited studies, the age effects become apparent around the age of 70 years. In the current study the average age was 72 years, which means an age effect could have made an impact on this study. In order to take this age effect into account in future research, the study design may need to group individuals according to cohort (e.g., 60-69 years and 70-79 years). With the limited participants in this study, however, this was not a viable option.

In the current study, BMI was protective of performance on reaction time tasks. After controlling for additional variables, BMI had one large effect size in relation to IRT ($r=-0.633, p=0.252$), which was in direct contrast to the association between PBF and reaction time. Increased PBF was detrimental to reaction time. Though, there were no significant associations between BMI and any other executive function tasks.

In the current study, as well as those found in the literature, it was common to find that only some cognitive domains were related to body fat. Gunstad, Lhotsky, Wendell, Ferrucci, and Zonderman (2010) used multiple cognitive tests to assess global cognitive function, attention, EF, memory, language, and visuospatial abilities. These researchers reported that BMI was related to better performance on some tests, but not on all attention and EF tasks. However, BMI was also related to poor performance in a separate EF task. Stanek et al. (2013) showed that BMI was not related to EF, language, or memory. In the same study, BMI was also related to poorer performance in the domains of attention and processing speed. These results, in addition to those of the current study, highlight the potential difficulties in interpreting results from this type of research. Such difficulties may stem from the complexity of the biological mechanisms being
researched in this topic. Researchers have not found an agreement on the definition of executive function, and have not determined the best way to evaluate it in humans. Likewise, body composition can be assessed with a variety of techniques that range from basic (e.g., BMI) to more specific (e.g., CT scan). Understandably, it is difficult to reach consistent, strong conclusions while scientists are still dealing with variability in measurement of the dependent variables.

In this investigation, education was significantly related to TRT and CRT. There were no associations between EF and age or socioeconomic status, even though research commonly cites both as important aspects of cognitive function (Hackman, Farah, & Meaney, 2010; vanHorren et al., 2007). Age did, however, have large effect sizes in relation to ER ($r=0.544$, $p=0.104$), GZ ($r=-0.522$, $p=0.122$) value, and SKL ($r=-0.549$, $p=0.1$) value. As expected, increased age was related to poorer performance on the outcomes of the d2 test. SES, conversely, only had one medium effect size worth noting. SES accounted for 23.6% of the variance in IRT. A potential explanation for these findings is the small sample size and relatively similar socioeconomic background of the participants.

RPE, an indication of intensity, was the only other variable significantly related to any outcomes of cognitive function. An association between RPE and cognitive function has not been cited in previous research. If there is truly an association between RPE and cognitive function it could have to do with research that suggests RPE is related to aerobic capacity (Habibi, Dehghau, Moghiseh, & Hasanzadeh, 2014). Colcolmbe and colleagues (2004) showed high aerobic fitness to be correlated with larger volumes of prefrontal and temporal gray matter. In that study, it was also found that aerobic activity was related to changes in areas of brain activation as measured by functional magnetic resonance imaging (fMRI). Individuals who
showed greater activity in the superior parietal cortex and middle frontal gyrus performed significantly better on tests of selective attention. However, more research would be needed to determine the true nature of a possible relationship between RPE and cognition. In the current study there was a relationship between RPE and some outcomes of EF. However, there was no relationship between 6MWT distance and EF. Based on the results of this study, perceived effort was related to cognitive function, but aerobic performance was not necessarily related to cognitive function.

The multiple and linear regression models did not significantly predict differences in cognitive function due to PBF or BMI, although the models were useful to analyze differences in the relative contribution of the dependent variables to executive function. There is the potential for PBF to predict cognitive function differently than BMI. For example, this was shown by PBF BIA predicting 14.6% more of the variance in ER than BMI. Additionally, PBF ADP was a significant predictor of ER when age, gender, education, distance walked, and hypertension/hypertensive medications were accounted for, while PBF BIA and BMI were not. It is important to note, though, that many of the regression models for BMI and PBF were comparable and not significantly different.

Limitations

This study was limited by the sample size (N=10). As a result, the findings have limited generalizability because the characteristics of the participants were similar (e.g., SES, education). Recruiting participants was challenging based on the strict exclusion criteria (e.g., few contraindications regarding health or medications), as well as the sensitive subject matter. Body fat and cognitive function are both topics that can be uncomfortable for an individual to assess. Further, necessary health information (e.g., current medication use) could make possible
participants unwilling to volunteer for fear of being excluded from the study. An additional limitation of the study is that it was cross-sectional research. Cross-sectional research only allows for a brief glimpse into the lives of the participants and does not examine how the relationship between physical and behavioral variables affect change over time. As previously mentioned, the current design may have allowed for individuals with pre-clinical dementia to be unknowingly included. However, this was taken into consideration by using the MoCA, an assessment designed to identify individuals likely to have MCI, which often progresses into dementia.

Future Research

In the literature review, it was common to find results covering every possible outcome. This could be because, in addition to body fat, there are many other variables that can influence cognitive function. There is well documented evidence that physical activity, education, socioeconomic status, cardiovascular risk factors (e.g., high blood pressure, high cholesterol), smoking status, alcohol use, age, and certain medications can affect cognitive function (Spirduso, Francis, & MacRae, 2005). In a research setting it is difficult to account for each of these variables. Additionally, there is still much debate over the best ways to assess cognitive function. As a result, there are many different tests of cognitive function, but no test has served as a standard for research. In this instance, it could be that inconsistencies among findings do not arise from what researchers chose to study, but how they chose to measure it. Future research may benefit from the use of brain imaging techniques in conjunction with cognitive tests. This would allow researchers to have a more detailed description of the relative health of each participants’ brain function.
Another important consideration for future research is recent evidence that resistance training can improve cognitive function. A review by Liu-Ambrose and Donaldson (2009) concluded that resistance training benefits cognitive function in older adults by increasing levels of insulin-like growth factor-1 (IGF-1) and decreasing serum levels of homocysteine. IGF-1 is a growth factor that promotes neuronal growth and survival. Homocysteine, at increased levels, is associated with neuropathologies, including Alzheimer's Disease. Liu-Ambrose et al. (2010) studied the effects of resistance training on executive function in women. In their 12 month study, resistance training, as opposed to balance and tone training, improved performance on tests of attention and conflict resolution. This study, in addition to others, suggest that strength training benefits general health as well as cognitive health. Based on the findings in the literature, it may be suggested that researchers in the future account for the aerobic capacity as well as resistance training status of each individual.

Finally, due to findings in the literature that show inflammation could influence cognitive function [see Jankowsky & Patterson, (1999) and Parrot & Greenwood, (2007) for a review], future research may benefit from evaluating the participants' eating habits. In the current study, PBF and BMI were one indication of possible chronic inflammation. However, this study failed to take into account the possible effects of inflammation that could be related to diet. Epidemiological studies show that diets including multiple weekly servings of fish (Morris et al., 2005) and multiple daily servings of fruits and vegetables (Panza et al., 2004) are more likely to benefit cognitive function. Alternatively, diets high in saturated and trans-fat are more likely to compromise cognitive function (Morris et al., 2003). As a result of this body of research, diet is an important consideration when cognitive function is being assessed.
Conclusion

The aim of this study was to determine whether percentage body fat (PBF) would yield a stronger relationship to EF in older adults than would body mass index (BMI). PBF and BMI were not significantly related to attention or reaction time, which are measures of executive function. This could be due to the small sample size (N=10) of this study. Executive function, relative to other cognitive abilities, is essential for helping older adults maintain their independence. As the population of older adults increases, it is important to determine the nature and mechanism of the relationship between body fat and cognitive function. As it becomes increasingly clear that body fat, not body mass, is responsible for affecting cognitive function, future research may benefit from using accurate ways to estimate body fat.
REFERENCES

Ardila, A. (2013). There are two different dysexecutive syndromes. *Journal of Neurological Disorders, 1*, 1-4.


Body Mass Index, Body Composition, and Cognitive Function in Adults 60 Years and Older


Body Mass Index, Body Composition, and Cognitive Function in Adults 60 Years and Older


Body Mass Index, Body Composition, and Cognitive Function in Adults 60 Years and Older


Informed Consent

Introduction: My name is Amy Ruthenberg. I am a master’s student in Kinesiology at Bowling Green State University in the Human Movement Sport and Leisure Studies (HMSLS) department. My advisor is Dr. Amy Morgan, HMSLS. This research is for my thesis requirement for graduation. I will be investigating the relationship between cognitive function and body composition in adults 60 years and older.

Purpose: The purpose of this research is to identify how different body fat techniques relate to cognitive function in adults 60 years and older. In this study we will use two different body fat estimates. These include bioelectrical impedance analysis (BIA) and air displacement plethysmography (ADP). We will also use an estimation of obesity, called body mass index (BMI). This study is the first study to specifically compare the three different techniques in how they relate to cognitive function. This may help us identify if BMI, BIA, or ADP is better to use when assessing cognition in future research.

As a participant, you will be given the opportunity to have your body composition measured by techniques known to be valid (i.e., BIA and ADP). These techniques are not easily available or may be expensive to the general public. Having an accurate idea of your body composition is essential to maintaining good health. We are happy to provide you resources for further information on this topic as well.

Procedure: Prior to coming in to the lab, you were asked to abstain from food or drink for four hours. Now that you are here, you will be asked to fill out a medical history questionnaire to determine if it is safe for your inclusion into this study. This is expected to take 5 to 10 minutes.

After the medical history questionnaire is completed, we will need to measure your heart rate (HR) and blood pressure (BP) while you are still seated.

Next, we will have you take The Montreal Cognitive Assessment (MoCA). This is a paper and pencil test with questions about memory, attention, and other cognitive functions. This test is out of 30 points and takes about 10 minutes to complete.

At this point, the researcher will determine if you are eligible to continue participating in the study. Reasons that you may not be eligible include high blood pressure, high resting heart rate, low cognitive test scores, the use of medications that affect the central nervous system (e.g., antidepressants) having a history of mental illness (e.g., depression, bipolar disorder), having a history of a neurological condition (e.g., dementias, Parkinson’s disease), or having had chest pain or a heart attack in the
past month. These criteria have two purposes. First, we want to make sure that it is safe for you to complete these procedures. Second, medications or conditions that may affect cognition can affect the results of this study. Therefore, we must make sure that the participants do not have these conditions. This will help us get the most accurate results. If you are not eligible to continue, we will inform you why. At this point you will not need to take more cognitive tests, but we can still provide you with body composition measurements if you so choose.

If you are eligible to continue, you will complete body fat estimation. You will be asked to stand and remove your shoes so that we can measure your height. Bioelectrical impedance analysis (BIA) measurements will be completed first. This device requires you to stand, barefoot, on electrodes and hold onto a bar with electrodes with both hands to complete the electrical circuit. Then, a harmless electrical current is sent through the body and results are shown on the screen. This test takes about one minute to complete.

Following BIA measurements, you will complete body fat estimation with the BOD POD. For most accurate results, you will be asked to wear form fitting clothing (i.e., swimsuit or single layer compression shorts and bras). Additionally, a cap will be provided to cover your head and all jewelry will need to be removed. Body weight will be measured with a scale. You will then be asked to sit quietly inside the chamber. The chamber door will be closed and two or three measurements, each lasting approximately 45 seconds, are taken while you are inside. If at any point you feel uncomfortable, you can signal for the test to be stopped through the window.

After body composition measurements, we will take a small break (about 5 to 10 min) and provide water, juice, and granola bars before moving on to the cognitive tests.

Cognitive function will be tested using two computerized tests, the d2 and the modified flanker task. In the d2 test, there will be fourteen lines of 47 randomly assorted letters (i.e., “p” and “d”). The letters have 1 to 4 dashes above or below them. You will be instructed to click on, with a computer mouse, only the letter “d” with two dashes above or below it (hence the name d2). You will be shown one line at a time for 20 seconds before moving on to the next line. The total time for this test is 5 minutes. Additionally, you will be given 4 practice trials of the d2 to help you become comfortable with the procedure.

After completion of the d2 test, you will complete the modified flanker task. In this test, you will be presented with a target arrow and “noise” arrows (i.e., two arrows surrounding the target on each side). The noise arrows can be congruent or incongruent. In the congruent condition, the arrows point in the same direction as the target arrow. In the incongruent condition, the arrows can point in the same or different directions as the target arrow. You will use the “control” keys on a keyboard to indicate which condition is shown. In the congruent condition, hit the right “control” key. In the incongruent condition, hit the left “control” key. 80 situations
will be presented (40 congruent and 40 incongruent); the test takes approximately 8.5 minutes to complete. Similar to the d2, you will be allowed practice trials to minimize the effects of learning.

Finally, you will complete the 6 minute walk test (6MWT). As the name would suggest, you are asked to walk as far as possible in 6 minutes. There will be a walking course with cones to mark the turning points. The researcher will count the number of laps completed to determine the final distance covered. The test will be done in a gymnasium in Eppler Complex at Bowling Green State University. The test can be stopped at any point if you feel uncomfortable and a chair will be nearby if you ever need to stop and sit down. You can rest at any time, but the timer will not be stopped. This is all expected to take 1 hour and 30 minutes.

Voluntary nature: Your participation is completely voluntary. You are free to withdraw at any time. You may decide to not do a particular task or discontinue participation at any time. Deciding to participate or not will not affect your relationship with Bowling Green State University.

Confidentiality: The consent forms, in hard copy, will be kept in a locked cabinet to which only my advisor or I will have a key. The experimental data (e.g., cognitive test scores, BMI, percent body fat) will be kept on a password protected computer. Your identity will be kept confidential and not revealed at any point following your participation in this study. Your name will be removed from the computer files and replaced with a number code.

Risks: As mentioned previously in the procedure, there are minor risks involved in participating in this study. This mainly involves physical exercise for the 6MWT. You are free to stop participation at any time. The researcher is trained in CPR/First Aid and will be present throughout the entire study. If in the days following participation in the 6MWT, you feel any negative health effects, I recommend that you visit your physician or a hospital. It is the participant’s responsibility to pay for the costs that may be incurred due to such a visit.

Contact Information: If at any point you have questions about the research or your participation, feel free to contact me or my advisor, Dr. Amy Morgan. Additionally, you may also contact the Human Subjects Review Board at 419-372-7716 or hsrp@bgsu.edu, if you have any questions about your rights as a participant in this research.

Principal Investigator: Amy Ruthenberg
I have been informed of the purposes, procedures, risks and benefits of this study. I have had the opportunity to have all my questions answered and I have been informed that my participation in completely voluntary. I agree to participate in this research.

_____________________________________ _________________
Participant Signature Date

____________________________________
Participant Name - Printed
MEDICAL HISTORY QUESTIONNAIRE

All information given is personal and confidential. It will enable us to better understand you and your health and fitness habits. In addition, we will use this information to classify your health status according to the American College of Sport Medicine (ACSM) recommendations for risk stratification (ACSM, 2009). Please let us know if and when you have changed your medication (dose & type), diet, exercise or sleeping habits within the past 24 or 48 hours. It is very important for you to provide us with this information.

NAME______________________________________________ AGE___________________ DATE___________________

OCCUPATION________________________________________________________________________________________

1. **FAMILY HISTORY**

Check each as it applies to a blood relative:

- **Heart Attack**
  - yes______ no______ unsure______
  - If yes, age at onset____ yrs; relation to you _____________

- **Sudden Death**
  - yes______ no______ unsure______
  - If yes, age at onset____ yrs; relation to you _____________

- **Coronary Revascularization**
  - yes______ no______ unsure______
  - If yes, age at onset____ yrs; relation to you _____________

  Father’s Age_____ Deceased_____ Age at death_____  
  (*Before 55 yr. in father or first-degree male relative)

  Mother’s Age_____ Deceased_____ Age at death_____  
  (*Before 65 yr. in mother or first-degree female relative)

2. **PERSONAL HISTORY**

Check each as it applies to you:

- **Age** (men ≥ 45 yr; women ≥ 55 yr)  
  - yes______ no______

- **Current Cigarette Smoking**  
  - yes______ no______ unsure______

- **Sedentary Lifestyle**  
  - yes______ no______ unsure______  
  - Person not participating in at least 30 min of moderate intensity physical activity on at least 3 days/wk for at least 3 months.

- **Obesity – BMI >30 kg m⁻²**  
  - yes______ no______ unsure______
  - If yes, give value: kg m⁻²
  - Waist circum. > 40” men; 35” women: yes______ no______

- **High Blood Pressure**  
  - yes______ no______ unsure______
  - Systolic Blood Pressure >140mmHg or diastolic >90mmHg
  - If yes, give value: / mmHg.

- **Dyslipidemia**  
  - yes______ no______ unsure______
  - Total Serum Cholesterol >200 mg dl⁻¹; value: __________ mg dl⁻¹
  - LDL-C ≥ 130 mg dl⁻¹; value: __________ mg dl⁻¹
  - HDL-C ≤ 40 mg dl⁻¹; value: __________ mg dl⁻¹
  - On lipid lowering medication: yes______ no______ unsure______

- **PreDiabetes**  
  - yes______ no______ unsure______
  - If yes, age of onset: __________ years
  - Impaired fasting glucose ≥ 100 mg dl⁻¹; value: __________ mg dl⁻¹
  - Impaired glucose tolerance test: yes______ no______
  - (Note: values confirmed by measures on two separate occasions)

- **Negative Risk Factor:**  
  - yes______ no______ unsure______
  - HDL ≥ 60 mg dl⁻¹; value: __________ mg dl⁻¹

Have you ever had:

- **Diabetes**  
  - yes______ no______ unsure______

- **Tuberculosis**  
  - yes______ no______ unsure______

- **Heart Attack**  
  - yes______ no______ unsure______

- **Angina**  
  - yes______ no______ unsure______

- **EKG Abnormalities**  
  - yes______ no______ unsure______

- **Asthma**  
  - yes______ no______ unsure______

- **Emphysema**  
  - yes______ no______ unsure______

- **Surgery**  
  - yes______ no______ unsure______

- **Stroke**  
  - yes______ no______ unsure______

- **Severe Illness**  
  - yes______ no______ unsure______

- **Hospitalized**  
  - yes______ no______ unsure______

- **Black Outs**  
  - yes______ no______ unsure______

- **Gout**  
  - yes______ no______ unsure______

- **Nervousness**  
  - yes______ no______ unsure______

- **Joint Problems**  
  - yes______ no______ unsure______

- **Depression**  
  - yes______ no______ unsure______

- **Chest Pain**  
  - yes______ no______ unsure______

- **Arm Pain**  
  - yes______ no______ unsure______

- **Shortness of Breath**  
  - yes______ no______ unsure______

- **Indigestion**  
  - yes______ no______ unsure______

- **Ulcers**  
  - yes______ no______ unsure______

- **Overweight**  
  - yes______ no______ unsure______

- **Hernia**  
  - yes______ no______ unsure______

- **Back Pain**  
  - yes______ no______ unsure______

- **Leg Cramps**  
  - yes______ no______ unsure______

- **Low Blood Pressure**  
  - yes______ no______ unsure______

- **Insomnia**  
  - yes______ no______ unsure______
For Office Use Only

Sum of positive and negative *CVD risk factors* (according to Table 2-3 ACSM (2009)

*NOTE: All risk factors are explained verbally to each person completing the questionnaire.*

Classification according to ACSM (2009) (check one): _____ Low risk; _____ Moderate risk; _____ High risk

3. MEDICAL HISTORY

Name of your physician__________________________________________________________________________________

Date of your most recent physical examination________________________________________________________________

What did the physical examination include?__________________________________________________________________

Have you ever had an exercise EKG? Yes_______ No________

Are you presently taking any medications? Yes_______ No_______ List name and dosage

Have you ever taken:

<table>
<thead>
<tr>
<th>Medication</th>
<th>Yes</th>
<th>No</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digitalis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitroglycerin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Blood Pressure Medication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedatives</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inderal</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. EXERCISE HISTORY

Do you exercise? Yes_______ No________ What activity_____________________________________________________

How long have you been exercising?_______________________________________________________________________

How many days do you exercise? How many minutes per day?______________________________________________

What kinds of shoes do you work out in?_________________________________________________________________

Where do you usually exercise?________________________________________________________________________

Do you monitor your pulse during your workout?__________________________________________________________

Do you believe nutritional supplements can have a positive effect on performance?

<table>
<thead>
<tr>
<th>Rating</th>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Definitely Not</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Maybe</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Definitely</td>
</tr>
</tbody>
</table>
5. HEALTH HISTORY

<table>
<thead>
<tr>
<th>Height</th>
<th>Weight</th>
<th>At Age 20</th>
<th>At Age 30</th>
<th>At Age 40</th>
<th>One Year Ago</th>
<th>Most Weighed Ago</th>
<th>Weighed After Age 20</th>
<th>Least Weighed</th>
</tr>
</thead>
</table>

Do you use Health Foods? Yes____ No_____ List___________________________________________________

Do you take Vitamin pills? Yes____ No_____ List___________________________________________________

Approximate your daily intake: Coffee_______ tea_______ coke_______ beer_______ wine_______ liquor_______

Do you smoke or use tobacco products? Yes____ No_____  
If yes, approximate your daily usage: Cigarettes______ Cigars______ Pipes______ Chewing Tobacco_______

Did you ever smoke? Yes_____ No_____  How many years?___________ Age when you quit_________

Approximate the number of hours you work per week?___________ Vacations weeks per year _____________

Home Status: Very happy__________  Pleasant__________  Difficult__________  Problem__________

Work Status: Very happy__________  Pleasant__________  Difficult__________  Problem__________

Do you feel you are stressed? Yes____ No_____ Unsure_________

Are you worried about your health? Yes____ No_____ Unsure_________

6. APPROXIMATE A TYPICAL 24 HOUR DAY FOR YOU

Number of hours:

<table>
<thead>
<tr>
<th>Work</th>
<th>Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV</td>
<td>TV</td>
</tr>
<tr>
<td>Relaxation/Leisure activities</td>
<td>Relaxation/Leisure activities</td>
</tr>
<tr>
<td>Driving/Riding</td>
<td>Driving/Riding</td>
</tr>
<tr>
<td>Eating</td>
<td>Eating</td>
</tr>
<tr>
<td>Exercise</td>
<td>Exercise</td>
</tr>
<tr>
<td>Sleep</td>
<td>Sleep</td>
</tr>
<tr>
<td>TOTAL</td>
<td>TOTAL</td>
</tr>
</tbody>
</table>

Additional information from client interview to further assess health/coronary risk status:

_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________
APPENDIX C. SUPPLEMENTAL MEDICAL HISTORY QUESTIONNAIRE

Name:

Gender:

Are you currently taking:

- Stimulants  yes______no_____unsure______
- Anxiolytics  yes______no_____unsure______
- Antidepressants yes______no_____unsure______
- Antipsychotics yes______no_____unsure______
- Anticonvulsants yes______no_____unsure______

Have you ever been diagnosed with:

- Mental illness (including mood disorders, anxiety disorders, psychotic disorders, personality disorders, obsessive-compulsive disorder, post-traumatic stress disorder)
  yes______no_____unsure______
- Neurological disorder (including dementias, Parkinson’s disease, epilepsy, ALS)
  yes______no_____unsure______
- Have you ever been admitted to a treatment program for substance abuse?
  yes______no_____unsure______
What is the highest level of education you have completed?
- 8th grade
- High School/GED
- Some college
- Trade/vocational training
- Associate’s degree
- Bachelor’s degree
- Master’s degree
- Doctoral degree
- Professional degree (e.g., M.D.)
- Other

What is your average household income?
- Under $10,000
- $10,000-$19,999
- $20,000-$29,999
- $30,000-$39,999
- $40,000-$49,999
- $50,000-$74,999
- $75,000-$99,999
- $100,000-$150,000
- Over $150,000
- Would rather not say
Montreal Cognitive Assessment (MoCA)

Nasreddine Z.


Administration and Scoring Instructions

Time to administer the MoCA is approximately 10 minutes. The total possible score is 30 points; a score of 26 or above is considered normal.

1. Alternating Trail Making:
   Administration: The examiner instructs the subject: "Please draw a line, going from a number to a letter in ascending order. Begin here [point to (1)] and draw a line from 1 then to A then to 2 and so on. End here [point to (E)]."
   Scoring: Allocate one point if the subject successfully draws the following pattern: 1 -A- 2- B- 3- C- 4- D- 5- E, without drawing any lines that cross. Any error that is not immediately self-corrected earns a score of 0.

2. Visuoconstructional Skills (Cube):
   Administration: The examiner gives the following instructions, pointing to the cube: "Copy this drawing as accurately as you can, in the space below".
   Scoring: One point is allocated for a correctly executed drawing.
   • Drawing must be three-dimensional
   • All lines are drawn
   • No line is added
   • Lines are relatively parallel and their length is similar (rectangular prisms are accepted)

   A point is not assigned if any of the above-criteria are not met.

3. Visuoconstructional Skills (Clock):
   Administration: Indicate the right third of the space and give the following instructions: "Draw a clock. Put in all the numbers and set the time to 10 after 11".
   Scoring: One point is allocated for each of the following three criteria:
   Contour (1 pt.): the clock face must be a circle with only minor distortion acceptable (e.g., slight imperfection on closing the circle);
   Numbers (1 pt.): all clock numbers must be present with no additional numbers; numbers must be in the correct order and placed in the approximate quadrants on the clock face; Roman numerals are acceptable; numbers can be placed outside the circle contour;
   Hands (1 pt.): there must be two hands jointly indicating the correct time; the hour hand must be clearly shorter than the
minute hand; hands must be centred within the clock face with their junction close to the clock centre.

A point is not assigned for a given element if any of the above-criteria are not met.

4. Naming:
**Administration:** Beginning on the left, point to each figure and say: “Tell me the name of this animal”.
**Scoring:** One point each is given for the following responses: (1) camel or dromedary, (2) lion, (3) rhinoceros or rhino.

5. Memory:
**Administration:** The examiner reads a list of 5 words at a rate of one per second, giving the following instructions: “This is a memory test. I am going to read a list of words that you will have to remember now and later on. Listen carefully. When I am through, tell me as many words as you can remember. It doesn’t matter in what order you say them”. Mark a check in the allocated space for each word the subject produces on this first trial. When the subject indicates that (s)he has finished (has recalled all words), or can recall no more words, read the list a second time with the following instructions: “I am going to read the same list for a second time. Try to remember and tell me as many words as you can, including words you said the first time.” Put a check in the allocated space for each word the subject recalls after the second trial.
At the end of the second trial, inform the subject that (s)he will be asked to recall these words again by saying, “I will ask you to recall those words again at the end of the test.”
**Scoring:** No points are given for Trials One and Two.

6. Attention:
**Forward Digit Span:** **Administration:** Give the following instruction: “I am going to say some numbers and when I am through, repeat them to me exactly as I said them”. Read the five number sequence at a rate of one digit per second.
**Backward Digit Span:** **Administration:** Give the following instruction: “Now I am going to say some more numbers, but when I am through you must repeat them to me in the backwards order.” Read the three number sequence at a rate of one digit per second.
**Scoring:** Allocate one point for each sequence correctly repeated, (N.B.: the correct response for the backwards trial is 2-4-7).
**Vigilance:** **Administration:** The examiner reads the list of letters at a rate of one per second, after giving the following instruction: “I am going to read a sequence of letters. Every time I say the letter A, tap your hand once. If I say a different letter, do not tap your hand”.
**Scoring:** Give one point if there is zero to one errors (an error is a tap on a wrong letter or a failure to tap on letter A).
**Serial 7s:** **Administration:** The examiner gives the following instruction: “Now, I will ask you to count by subtracting seven from 100, and then, keep subtracting seven from your answer until I tell you to stop.” Give this instruction twice if necessary.
**Scoring:** This item is scored out of 3 points. Give no (0) points for no correct subtractions, 1 point for one correction subtraction, 2 points for two-to-three correct subtractions, and 3 points if the participant successfully makes four or five correct
subtractions. Count each correct subtraction of 7 beginning at 100. Each subtraction is evaluated independently; that is, if the participant responds with an incorrect number but continues to correctly subtract 7 from it, give a point for each correct subtraction. For example, a participant may respond “92 – 85 – 78 – 71 – 64” where the “92” is incorrect, but all subsequent numbers are subtracted correctly. This is one error and the item would be given a score of

7. Sentence repetition:
Administration: The examiner gives the following instructions: “I am going to read you a sentence. Repeat it after me, exactly as I say it [pause]: I only know that John is the one to help today.” Following the response, say: “Now I am going to read you another sentence. Repeat it after me, exactly as I say it [pause]: The cat always hid under the couch when dogs were in the room.”
Scoring: Allocate 1 point for each sentence correctly repeated. Repetition must be exact. Be alert for errors that are omissions (e.g., omitting "only", "always") and substitutions/additions (e.g., "John is the one who helped today;" substituting "hides" for "hid", altering plurals, etc.).

8. Verbal fluency:
Administration: The examiner gives the following instruction: “Tell me as many words as you can think of that begin with a certain letter of the alphabet that I will tell you in a moment. You can say any kind of word you want, except for proper nouns (like Bob or Boston), numbers, or words that begin with the same sound but have a different suffix, for example, love, lover, loving. I will tell you to stop after one minute. Are you ready? [Pause] Now, tell me as many words as you can think of that begin with the letter F. [time for 60 sec]. Stop.”
Scoring: Allocate one point if the subject generates 11 words or more in 60 sec. Record the subject’s response in the bottom or side margins.

9. Abstraction:
Administration: The examiner asks the subject to explain what each pair of words has in common, starting with the example: “Tell me how an orange and a banana are alike”. If the subject answers in a concrete manner, then say only one additional time: “Tell me another way in which those items are alike”. If the subject does not give the appropriate response (fruit), say, “Yes, and they are also both fruit.” Do not give any additional instructions or clarification.
After the practice trial, say: “Now, tell me how a train and a bicycle are alike”. Following the response, administer the second trial, saying: “Now tell me how a ruler and a watch are alike”. Do not give any additional instructions or prompts.
Scoring: Only the last two item pairs are scored. Give 1 point to each item pair correctly answered. The following responses are acceptable:
Train-bicycle = means of transportation, means of travelling, you take trips in both;
Ruler-watch = measuring instruments, used to measure.
The following responses are not acceptable: Train-bicycle = they have wheels;
Ruler-watch = they have numbers.

10. Delayed recall:
Administration: The examiner gives the following instruction: “I read some words to you earlier, which I asked you to remember. Tell me as many of those words as you
can remember. Make a check mark ( ) for each of the words correctly recalled spontaneously without any cues, in the allocated space.  
**Scoring:** *Allocate 1 point for each word recalled freely without any cues.*

**Optional:**
Following the delayed free recall trial, prompt the subject with the semantic category cue provided below for any word not recalled. Make a check mark ( ) in the allocated space if the subject remembered the word with the help of a category or multiple-choice cue. Prompt all non-recalled words in this manner. If the subject does not recall the word after the category cue, give him/her a multiple choice trial, using the following example instruction, “Which of the following words do you think it was, NOSE, FACE, or HAND?”

Use the following category and/or multiple-choice cues for each word, when appropriate:
- **FACE:** category cue: part of the body multiple choice: nose, face, hand
- **VELVET:** category cue: type of fabric multiple choice: denim, cotton, velvet
- **CHURCH:** category cue: type of building multiple choice: church, school, hospital
- **DAISY:** category cue: type of flower multiple choice: rose, daisy, tulip
- **RED:** category cue: a colour multiple choice: red, blue, green

**Scoring:** *No points are allocated for words recalled with a cue.* A cue is used for clinical information purposes only and can give the test interpreter additional information about the type of memory disorder. For memory deficits due to retrieval failures, performance can be improved with a cue. For memory deficits due to encoding failures, performance does not improve with a cue.

**11. Orientation:**

**Administration:** The examiner gives the following instructions: “Tell me the date today”. If the subject does not give a complete answer, then prompt accordingly by saying: “Tell me the [year, month, exact date, and day of the week].” Then say: “Now, tell me the name of this place, and which city it is in.”

**Scoring:** Give one point for each item correctly answered. The subject must tell the exact date and the exact place (name of hospital, clinic, office). No points are allocated if subject makes an error of one day for the day and date.

**TOTAL SCORE:** Sum all subscores listed on the right-hand side. Add one point for an individual who has 12 years or fewer of formal education, for a possible maximum of 30 points. A final total score of 26 and above is considered normal.
Montreal Cognitive Assessment (MOCA)

Name: [ ]
Sex: [ ]
Date of birth: [ ]

Points:
- Copy cube: [ ]
- Draw clock (ten past eleven): [ ]
- Contour numbers hands: [ ]
- No points [ ]

Scores:
- Memory: [ ]
- Attention: [ ]
- Language: [ ]
- Abstraction: [ ]
- Delayed recall: [ ]
- Orientation: [ ]

©Z.Nasreddine MD Version November 7, 2004
Normal 26/30
Add 1 point if ≤ 12 yr olds
www.mocatest.org
Traduction: Montreal Cognitive Assessment (MoCA)

Nasreddine Z.


Instructions pour l'administration et la cotation

Le temps d’exécution est de dix minutes approximativement. Le nombre de points maximum est de 30; un score de 26 et plus est considéré normal.

1. Alternance conceptuelle :

Administration : L’examinateur donne les instructions suivantes, en indiquant l’endroit approprié sur la feuille : « Je veux que vous traciez une ligne en alternant d’un chiffre à une lettre, tout en respectant l’ordre chronologique et l’ordre de l’alphabet. Commencez ici (indiquez le 1) et tracez la ligne vers la lettre A, ensuite vers le 2, etc. Terminez ici (indiquez le E).

Cotation : Un point est alloué si le sujet réussit la séquence suivante :
1 – A – 2 – B – 3 – C – 4 – D – 5 – E

N’allouez aucun point si une erreur n’est pas immédiatement corrigée par le sujet.

2. Capacités visuoconstructives (Cube) :

Administration : L’examinateur donne les instructions suivantes, indiquant cube : «Je veux que vous copiez ce dessin le plus précisément possible».

Cotation : Un point est alloué si le dessin est correctement réalisé.

• Le dessin doit être tridimensionnel
• Toutes les arêtes sont présentes
• Il n’y a pas d’arête supplémentaire
• Les arêtes sont relativement parallèles et de même longueur approximative (les prismes rectangulaires sont acceptables)

Le point n’est pas alloué si les critères ci-dessus ne sont pas respectés.

3. Capacités visuoconstructives (Horloge) :

Administration : Indiquant l’espace approprié, l’examinateur donne les instructions suivantes : «Maintenant je veux que vous dessiniez une horloge en plaçant tous les chiffres et indiquant l‘heure à 11h10».

Cotation : Un point est alloué pour chacun des trois critères suivants.
• Contour (1 pt.) : Le contour doit être un cercle avec peu de déformation.
  (e.g. déformation mineure de la fermeture du cercle)
• Chiffres (1 pt.): Tous les chiffres doivent être présents sans aucun chiffre
  en surplus; les chiffres doivent être dans le bon ordre et bien positionnés ; les chiffres Romains sont
  acceptés ainsi que les chiffres inscrits à l'extérieur du contour.
• Aiguilles (1 pt.): Les deux aiguilles doivent indiquer la bonne heure ;
  l’aiguille de l’heure doit être clairement plus petite
  que l’aiguille des minutes. La jonction des aiguilles
  doit être proche du centre de l’horloge.

• Un point n’est pas alloué si les critères ci-dessus ne sont pas respectés.

4. Dénomination :

Administration : L’examinateur demande au sujet de nommer le nom de chacun des
animaux, de la gauche vers la droite.
Cotation : Un point est alloué pour la dénomination exacte de chacun des dessins :
(1) chameau ou dromadaire (2) lion (3) rhinocéros ou rhino.

5. Mémoire :

Administration : L’examinateur lit une liste de 5 mots à un rythme de 1 par seconde,
après avoir donné les instructions suivantes : «Ceci est un test de mémoire. Je vais
vous lire une liste de mots que vous aurez à retenir. Écoutez attentivement et quand
j’aurai terminé, je veux que vous me redisiez le plus de mots possible dont vous
pouvez vous rappeler, dans l’ordre que vous voulez». L’examinateur lit la liste de
mots une première fois et identifie par un crochet ( ), dans l’espace réservé à cet
effet, chacun des mots énoncés par le sujet. Lorsque le sujet a terminé (s’est
souvenu de tous les mots), ou s’il ne peut se rappeler davantage de mots,
l’examinateur relit la liste de mots après avoir donné les instructions suivantes :
«Maintenant je vais lire la même liste de mots une seconde fois. Essayez de vous
rappeler du plus grand nombre de mots possible, y compris ceux que vous avez
énoncés la première fois». L’examinateur identifie par un crochet, dans l’espace
réservé à cet effet, chacun des mots énoncés au deuxième essai. À la fin du
deuxième essai, l’examinateur informe le sujet qu’il devra retenir ces mots car il aura
à les redire à la fin du test.
Cotation : Aucun point n’est alloué pour le rappel immédiat après le premier et le
deuxième essai.

6. Attention :

Empan numérique : Administration: L’examinateur lit une séquence de 5 chiffres à un
rythme de 1 par seconde, après avoir donné les instructions suivantes : «Je vais
vous dire une série de chiffres, et lorsque j’aurai terminé, je veux que vous répétiez
ces chiffres dans le même ordre que je vous les ai présentés».
Empan numérique inversé : Administration : L’examinateur lit ensuite une séquence
de 3 chiffres à un rythme de 1 par seconde, après avoir donné les instructions
séquences : «Je vais vous dire une série de chiffres, et lorsque j’aurai terminé, je veux que vous répétiez ces chiffres dans l’ordre inverse que je vous les ai présentés».

Cotation : Un point est alloué pour chacune des séquences correctement répétées (N.B. : la séquence exacte de l’empan à rebours est 2-4-7).

Concentration : Administration : L’examinateur lit une série de lettres à un rythme de 1 par seconde, après avoir donné les instructions suivantes : «Je vais vous lire une série de lettres. Chaque fois que je dirai la lettre A, vous devrez taper de la main une fois. Lorsque je dirai une lettre différente du A, vous ne taperez pas de la main».

Cotation : Aucun point n’est alloué s’il y a plus d’une erreur (e.g. tape sur une mauvaise lettre ou omet de taper sur une lettre A).

Calcul sérié : Administration : L’examinateur donne les instructions suivantes : «Maintenant je veux que vous calculez 100 - 7, et ensuite, continuez de soustraire 7 de votre réponse, jusqu’à ce que je vous dise d’arrêter». L’examinateur peut répéter les instructions une deuxième fois si nécessaire.

Cotation : Cet item est coté sur 3 points. N’allouer aucun point si aucune soustraction n’est correcte. 1 point pour 1 soustraction correcte. 2 points pour 2 ou 3 soustractions correctes. 3 points pour 4 ou 5 soustractions correctes. Chaque soustraction est évaluée individuellement. Si le sujet fait une erreur de soustraction mais par la suite soustrait correctement le chiffre 7 mais à partir du chiffre erroné, les points sont alloués lorsque la soustraction du chiffre 7 est correcte, e.g. 100 - 7 = 92 - 85 - 78 -71 –64. Le “92” est incorrect mais tous les chiffres subséquents sont corrects. Donc il s’agit de 4 soustractions correctes, le score est de 3 points.

7. Répétition de phrases :

Administration : L’examinateur donne les instructions suivantes : «Maintenant je vais vous lire une phrase et je veux que vous la répétez après moi : «Le colibri a déposé ses œufs sur le sable». Ensuite, l’examinateur dit : «Maintenant je vais vous lire une seconde phrase et vous allez la répéter après moi : L’argument de l’avocat les a convaincus».

Cotation : Un point est alloué pour chaque phrase correctement répétée. La répétition doit être exacte. L’examinateur sera vigilant pour les erreurs d’omission, de substitution et d’addition.

8. Fluidité verbale :

Administration : L’examinateur donne les instructions suivantes : «Je veux que vous me disiez le plus de mots possible qui débutent par une lettre de l’alphabet que je vais vous dire. Vous pouvez dire n’importe quelle sorte de mot, sauf les noms propres, des chiffres, les conjugaisons de verbe (e.g. mange, mangerons, mangerez) et les mots de même famille (e.g. pomme, pommette, pommier). Je vais vous dire d’arrêter après une minute. Êtes-vous prêt ? Maintenant, dites le plus de mots possible qui commencent par la lettre F».

Cotation : Un point est alloué si le sujet énonce 11 mots et plus en une minute.

9. Similitudes :

Administration : L’examinateur demande au sujet de donner le point commun entre deux items présentés, en illustrant par l’exemple suivant: « En quoi une orange et
une banane sont-elles semblables» ? Si le sujet fournit une réponse concrète, l’examinateur demande à une seule autre reprise : «Donnez-moi une autre raison pour laquelle une orange et une banane se ressemblent». Si le sujet ne donne pas la bonne réponse, dites : «oui, et elles sont toutes les deux des fruits». Ne pas donner d’autres instructions ou explications.


10. Rappel différé

Administration : L’examinateur donne les instructions suivantes : «Je vous ai lu une série de mots plus tôt dont je vous ai demandé de vous rappeler. Maintenant, dites-moi tous les mots dont vous vous rappelez»
L’examinateur identifie les mots correctement énoncés sans indice, par un crochet ( ) dans l’espace réservé à cet effet.
Cotation : Un point est alloué pour chacun des mots rappelés spontanément, sans indice.
Optionnel :
Pour les mots dont le sujet ne se rappelle pas spontanément, l’examinateur fournit un indice catégoriel (sémantique). Ensuite, pour les mots dont le sujet ne se rappelle pas malgré l’indice sémantique, l’examinateur fournit un choix de réponses et le sujet doit alors identifier le mot approprié. Les indices pour chacun des mots sont présentés ci-bas:
VISAGE : indice catégoriel : partie du corps choix de réponses : nez, visage, main
VELOURS : indice catégoriel : tissu choix de réponses : denim, coton, velour
ÉGLISE : indice catégoriel : bâtiment choix de réponses : église, école, hôpital
MARGUERITE : indice catégoriel : fleur choix de réponses : rose, marguerite, tulipe
ROUGE : indice catégoriel : couleur choix de réponses : rouge, bleu, vert
Cotation : Pas de points pour les mots rappelés avec indice. Identifier par un crochet ( ) dans l’espace approprié les mots qui ont été énoncés suite à un indice (catégoriel ou choix de réponse). L’apport d’indices fournit des informations cliniques sur la nature des difficultés mnésiques. Pour les difficultés de récupération de l’information, la performance peut être améliorée par les indices. Dans le cas de difficultés d’encodage, les indices n’améliorent pas la performance.

11. Orientation :

Administration : L’examinateur donne les instructions suivantes : «Dites-moi quelle date sommes-nous aujourd’hui» ? Si le sujet fournit une réponse incomplète, l’examinateur dit : «Dites-moi l’année, le mois, la date, et le jour exact». Ensuite, l’examinateur demande : «Maintenant, dites-moi comment s’appelle l’endroit où nous sommes présentement et dans quelle ville est-ce» ?
Cotation : Un point est alloué pour chacune des réponses exactement énoncées. Le sujet doit dire la date exacte et l’endroit exact (hôpital, clinique, bureau, etc.). Aucun point n’est alloué si le sujet se trompe d’une seule journée pour la date et le jour.

TOTAL :
Additionnez tous les points accumulés dans l’espace droit de la feuille, pour un maximum de 30 points. Ajouter un point si la scolarité du sujet est de 12 ans ou moins (si le MoCA est plus petit que 30). Un score égal ou supérieur à 26 est considéré normal.
Are you interested in learning about the health of your body and mind?

Are you...

- At least 60 years old
- Free of any current or pre-existing neurological condition (e.g., stroke, mental illness, dementia, Parkinson’s disease)
- Not on any medications that act on the central nervous system (e.g., antidepressants, anti-epileptics)
- Have no history of substance abuse
- Not claustrophobic

If so, we invite you to join a research study at Bowling Green State University!

Participants will receive body composition measures from top of the line technology, like the BOD POD!

If you are interested or have any questions, feel free to contact Amy Ruthenberg.

e-mail: amylr@bgsu.edu    phone number: 517-449-5754
APPENDIX F. HUMAN SUBJECTS REVIEW BOARD APPROVAL LETTER

DATE: January 29, 2015

TO: Amy Ruthenberg
FROM: Bowling Green State University Human Subjects Review Board

PROJECT TITLE: [700191-1] The relationship between body mass index, body fat, and executive function in adults 60 years and older.

SUBMISSION TYPE: New Project

ACTION: APPROVED

APPROVAL DATE: January 28, 2015
EXPIRATION DATE: January 27, 2016
REVIEW TYPE: Expedited Review

REVIEW CATEGORY: Expedited review category # 4

Thank you for your submission of New Project materials for this project. The Bowling Green State University Human Subjects Review Board has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

The final approved version of the consent document(s) is available as a published Board Document in the Review Details page. You must use the approved version of the consent document when obtaining consent from participants. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that you are responsible to conduct the study as approved by the HSRB. If you seek to make any changes in your project activities or procedures, those modifications must be approved by this committee prior to initiation. Please use the modification request form for this procedure.

You have been approved to enroll 65 participants. If you wish to enroll additional participants you must seek approval from the HSRB.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. All NON-COMPLIANCE issues or COMPLAINTS regarding this project must also be reported promptly to this office.

This approval expires on January 27, 2016. You will receive a continuing review notice before your project expires. If you wish to continue your work after the expiration date, your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date.

Good luck with your work. If you have any questions, please contact the Office of Research Compliance at 419-372-7716 or hsrb@bgsu.edu. Please include your project title and reference number in all correspondence regarding this project.
This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Bowling Green State University Human Subjects Review Board's records.