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## **Adiposity And Arterial Stiffness: Associations With Prefrontal Cortex Hemodynamic Response And Response Inhibition**

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ADIPOSITY AND ARTERIAL STIFFNESS: ASSOCIATIONS WITH PREFRONTAL  
CORTEX HEMODYNAMIC RESPONSE AND RESPONSE INHIBITION

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John William Capps IV

2020

## **DEDICATION**

*To my beloved wife, Veronica.*

*Thanks for your support and love throughout.*

*To my treasured Son, Juan Sebastian*

*Always follow your dreams.*

ADIPOSITY AND ARTERIAL STIFFNESS: ASSOCIATIONS WITH PREFRONTAL  
CORTEX HEMODYNAMIC RESPONSE AND RESPONSE INHIBITION

by

JOHN WILLIAM CAPPS IV, B.A.

THESIS

Presented to the Faculty of the Graduate School of

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## ABSTRACT

Obesity is a global health crisis associated with increased arterial stiffness, diminished brain reactivity, and diminished executive functioning. Inhibitory control, a specific domain of executive functioning, is known to be especially important to behaviors influencing health. The current study aimed to determine if increased adiposity and arterial stiffness were associated with performance and brain activation for two inhibitory control subtypes, response restraint, and response cancellation. Carotid-femoral pulse wave velocity, the Cued Go/No-go Task, the Stop Signal Task, and functional Near-Infrared Spectroscopy (fNIRS) were used to investigate these relationships. Pearson correlations indicated that slower stop-signal reaction time was associated with a greater waist-to-hip ratio ( $r = .469$ ) and a greater pulse wave velocity ( $r = .400$ ). fNIRS monitoring during the Cued Go/No-go task revealed that a lower mean level of oxyhemoglobin in the left prefrontal cortex was associated with greater hip-to-waist ratio ( $r = -.348$ ) and pulse wave velocity ( $r = -.372$ ). fNIRS monitoring during the Stop Signal task also revealed that a lower mean level of oxyhemoglobin in the right prefrontal cortex was associated with greater body mass index ( $r = -.308$ ) and body fat percentage ( $r = -.288$ ). Hierarchical regression revealed that pulse wave velocity added a significant explanation of stop-signal reaction times, above and beyond the variance explained by age, socioeconomic status, and body fat percentage ( $\Delta R^2 = .09$ ). Our results further support that adiposity and arterial stiffness are related to brain hemodynamic response and particular inhibitory control abilities and add that this relationship may be present in a younger adult population.

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## **CHAPTER 1: INTRODUCTION**

The rates of individuals who are overweight and obese are increasing among every age group globally (Blüher, 2019). Overweight and obese individuals are more likely to have chronic health issues including hypertension, dyslipidemia, type-2 diabetes, metabolic syndrome, and cardiovascular disease which contribute significantly to increased mortality (Flegal, Kit, Orpana, & Graubard, 2013; Must, Spadano, Coakley, Field, Colditz, & Dietz, 1999). Obesity also negatively impacts the cardiovascular system by increasing arterial stiffness, which further increases the risk of cardiovascular mortality, congestive heart failure, and stroke (Sutton-Tyrrell et al., 2005; Ohkuma et al., 2017). Therefore, the increase in the prevalence of obesity and its associated health conditions are stressing global healthcare systems (Lehnert, Sonntag, Konnopka, Riedel-Heller, & König, 2013; Ng et al., 2014).

Obesity is also associated with deficits and an increased decline in cognitive functioning (Arvanitakis, Capuano, Bennett, & Barnes, 2017; Goldschmidt, O'Brien, Lavender, Pearson, Grange, & Hunter, 2017; Gunstad, Lhotsky, Wendell, Ferrucci, & Zonderman, 2010). Furthermore, research demonstrates that high sugar/fat/calorie diets and sedentary behavior have a negative impact on cognitive performance (Smith, Hay, Campbell, & Trollor, 2011; Greenwood, & Winocur, 2005). These factors decrease cardiovascular system health, which is believed to be a major factor affecting brain functioning and subsequent cognitive performance (Davenport, Hogan, Eskes, Longman, & Poulin, 2012).

### **Cerebral Vascular Functioning**

Increased body fat is strongly associated with increased arterial stiffness and vascular dysfunction (Koskinen et al., 2009; Tremblay, Colley, Saunders, Healy, & Owen, 2010; Huynh et al., 2013; Short, Blackett, Gardner, & Copeland, 2009; Wildman, Mackey, Bostom,

Thompson, & Sutton-Tyrrell, 2003). Obesity-related vascular dysfunction has been shown to negatively affect the brain in several ways. First, the cerebral vascular response is blunted in obese populations (Hurr, Patik, Kim, & Brothers, 2017; Rodríguez-Flores, García-García, Cano-Nigenda, & Cantú-Brito, 2014). Second, vascular dysfunction due to a high-fat diet appears earlier in cerebral arterioles than in carotid arteries (Lynch et al., 2013). Finally, increased adipose tissue increases inflammation, which specifically harms cerebral vascular functioning (Chang, Chavan & Pavlov, 2019; Freeman, Haley-Zitlin, Rosenberger, & Granhom, 2013; Nishimura, Manabe, & Nagai, 2009; Nguyen, Kilcross, & Jenkins, 2014; Singer & Lumeng, 2017; Stough & Fard, 2019).

Since neurocognitive activity relies heavily on brain vasculature, vascular dysfunction may moderate the relationship between obesity and impairments in cognitive functioning (Davenport et al., 2012). Indeed, arterial stiffness has been associated with impairments in cognitive functioning (Howarth, Gleeson, & Attwell, 2012). For example, increased arterial stiffness is associated with higher rates of age-related cognitive decline (Mekari et al., 2019; Singer, Trollor, Baune, Sachdev, & Smith, 2014; Watson et al., 2008) and increased risk of dementia (Waldstein et al., 2008). Even in healthy middle-aged adults, longitudinal analyses show that arterial stiffness contributes to accelerating the rate of cognitive decline (Hajjar, Goldstein, Martin, & Quyyumi, 2016). These findings help demonstrate a link between vascular health and cognitive function.

### **Inhibitory Control**

Executive functions are the set of cognitive processes that are engaged in the control and monitoring of behavior and mental thought. These cognitive processes are needed for planning, flexible thinking, and self-control (Heitz, Redick, Hambrick, Kane, Conway, & Engle, 2006).

Inhibitory control, a subprocess of executive functioning, is the voluntary control (stopping, changing, or delaying) of a prepotent attentional, motor, or behavioral response (Logan, Cowan, & Davis 1984). As such, inhibitory control processes serve higher-level processes such as the focusing of attention, ignoring of irrelevant information, and controlling strong but inappropriate responses (Hasher, Lustig, & Zacks, 2007; Verbruggen et al., 2019).

Inhibitory control processes are recruited in the self-regulation of health-related behaviors such as the selection of food/meals, snacking, and physical activity levels (Baumeister, 2014; De Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2011). Increased body fat and obesity have been associated with poor inhibitory control abilities (Barkin, 2013; Batterink, Yokum, & Stice, 2010; Jasinska, Yasuda, Burant, Gregor, Khatri, Sweet, & Falk, 2012; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006; Maayan, Hoogendoorn, Sweat, & Convit, 2011). Increased access to food (especially rewarding high fat/sugar foods), a more sedentary lifestyle, and a prevalence of cues associated with unhealthy behaviors (ex. Food advertising) place an even greater role of inhibitory control processes on health (Appelhans, 2009; Wardle, 1988).

There are three types of consciously-driven, effortful inhibitory control processes: interference control, response flexibility, and response inhibition (see Figure 1.1). Response inhibition is further divided into two parts: response restraint and response cancellation. Response restraint involves a proactive process that occurs before the action happens while response cancellation involves a corrective process occurring after a response has been initiated (Schachar et al., 2007).

Response inhibition in particular has been linked to health behaviors and obesity. For example, women with obesity and sweet food addiction show poorer performance on measures

of response inhibition relative to controls. This poorer performance on this task was also associated with increased impulsivity (Hsu et al., 2017). Additionally, researchers have found that poorer response inhibition ability can predict weight gain (Guxens, Mendez, Julvez, et al., 2009; Osika & Montgomery, 2008; Nederkoorn et al., 2010).

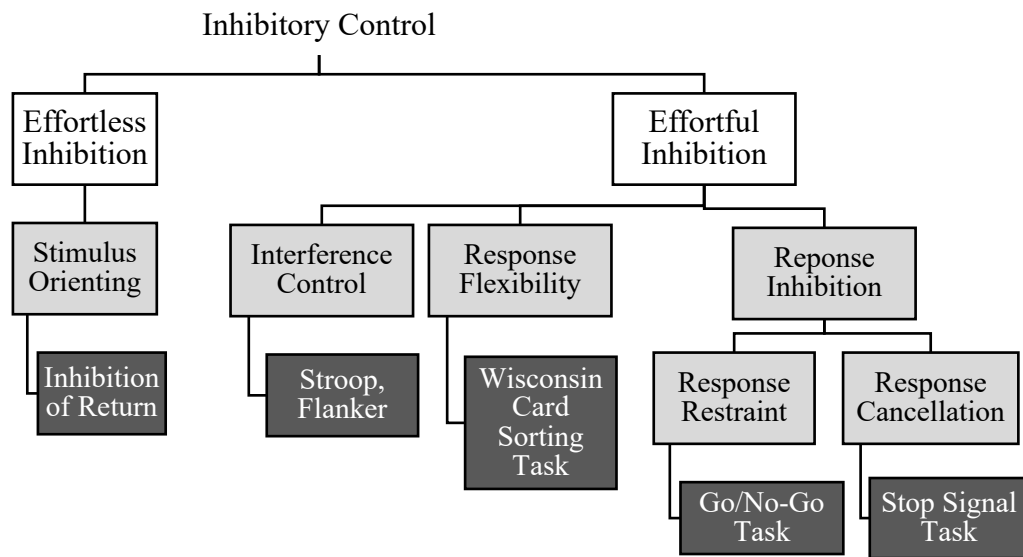


Figure 1.1: Divisions of Inhibitory Control and Tasks Used to Measure Abilities

*Note.* From Wikinson (2016)

Using imaging techniques such as functional Magnetic Resonance Imaging (fMRI) and function Near Infra-Red Spectroscopy (fNIRS), researchers have demonstrated that the prefrontal cortex (PFC) is highly involved in inhibition tasks. (Konishi, Nakajima, Uchida, Kikyo, Kameyama, & Miyashita, 1999; Schroeter, Zysset, Kruggel, & von Cramon, 2003). Better performance on inhibition tasks is associated with greater levels of oxyhemoglobin as measured by fNIRS (León-Carrion et al. 2008; Schroeter et al., 2002). The hemodynamic response in the PFC and performance on inhibition tasks is also affected by obesity. Compared to normal-weight individuals, individuals who were overweight and obese had decreased levels of

oxygenated hemoglobin (HbO<sub>2</sub>) in the prefrontal cortex. (Deng, Huang, Zhang, Qi, & Huang, 2017).

In contrast, individuals with better cardiovascular fitness have better performance on tasks of inhibition and increased oxygenated hemoglobin in the prefrontal cortex during the task (Dupuy et al., 2015). Moreover, Drigny et al., (2014) demonstrated that an exercise training program had positive effects on cerebral hemodynamic response and executive functioning. After the program, the participants' executive functioning and cerebral vascular response to exercise were both significantly improved. Taken alongside the information from studies involving obese individuals, these findings indicate that measuring hemodynamic response may be able to index the health of the blood supply in the frontal lobe (Davenport, Hogan, Eskes, Longman, & Poulin, 2012).

In sum, the literature demonstrates independent associations between vascular health, brain functioning, and cognitive performance. Even though researchers consider cerebral vascular response an important factor influencing cognitive function, few studies involve measures of vascular health, neuroimaging, and cognitive performance and even fewer which specifically consider the different types of inhibitory control abilities. The literature does establish that increased body fat is associated with vascular dysfunction and poorer executive control, yet, we identified no studies which explore the association between arterial stiffness, cerebral hemodynamic response, and response restraint and response cancellation abilities (Lavagnino, Arnone, Cao, Soares, & Selvaraj, 2016; Prickett, Brennan, & Stolwyk, 2015; Singer, Trollor, Baune, Sachdev, & Smith, 2014).



## **CHAPTER 2: CURRENT STUDY**

The objective of the current study was to determine if increased adiposity and arterial stiffness were associated with performance and brain activation for the inhibitory control subtypes, response restraint, and response cancellation. Correlational methodology was determined to be a sufficient initial step to investigating these relationships using a diverse sample of adults.

First, we wanted to establish that significant relationships existed between indices of adiposity (waist-to-hip ratio [WHR], body mass index [BMI], body fat percentage), pulse wave velocity, and measures of response restraint and response cancellation inhibition ability. Equally, we wanted to examine the relationships in which these indices of adiposity and arterial stiffness had with the mean level of oxygenated hemoglobin in the prefrontal cortex during these tasks.

To further explore the relationship between arterial stiffness and inhibitory control, we determined to what extent would the addition of pulse wave velocity and mean level of PFC oxyhemoglobin levels account for ability, above and beyond the predictive associations from age, socioeconomic status (SES), and body fat percentage. By the addition of first age and SES in the first step of the hierarchical regression, we can account for variables that are already known to be highly influential in neurocognitive abilities (Farah, 2017; Noble, McCandliss, & Farah, 2007; Oswald et al., 2019). Furthermore, since prior studies have established a clear association negative between obesity and inhibitory control, an indicator of body fat content was also included in the first step of the hierarchical regression. These health and cognitive studies used body mass index, which was developed to as a quick and easy way to index a person's fat composition, our supposition was that body fat percentage would be a more robust indicator of general adiposity that is less impacted by muscle mass (Arvanitakis, Capuano, Bennett, &

Barnes, 2017; Goldschmidt, O'Brien, Lavender, Pearson, Grange, & Hunter, 2017; Ortega, Sui, Lavie, & Blair, 2016).

Our predictions were as follows:

Prediction 1) Greater adiposity and pulse wave velocity would be associated with decreased response restraint (increased errors on vertical cue no-go trials of the Go/No-go task) and decreased response cancellation (increased stop-signal reaction time on the Stop Signal task).

Prediction 2) Greater adiposity and pulse wave velocity would be associated with blunted hemodynamic response (lower HbO<sub>2</sub> and greater HHb) in the PFC during these tasks.

Prediction 3) Pulse wave velocity would account for significant variance of performance above and beyond the covariates (age, SES, and body fat percentage).

Prediction 4) The addition of task-related PFC oxygenated hemoglobin levels would also be able to account for significant variance in inhibition performance scores.

## CHAPTER 3: METHODS

### Participants

A power analysis was conducted using G\*Power for small, medium, and large effect sizes to determine the required sample size (Faul, Erdfelder, Buchner, & Lang, 2009). Since past research using neuroimaging has found statistically significant results using samples much lower than 50, therefore, a medium to large effect was assumed (Deng et al., 2017; Dupuy et al., 2015). Results from the power analysis ( $\alpha = .05$ , power = .80) revealed that to detect a medium effect ( $f^2 = .20$ ) 73 participants were required. To detect a large effect ( $f^2 = .35$ ) at the levels of  $\alpha$  and power stated prior, 37 participants were required.

Participants were recruited using flyers, social media, and craigslist ads (See Appendix A). Ads described the study, the \$15 incentive, and invited only individuals who were; 18-50 years, non-smokers, had no major medical conditions, no known skin allergies, and no head injuries. Digital recruitment ads were shared via Facebook in local Facebook groups while printed flyers were posted in public places (i.e. University, Public Library). All posts, flyers, or potential participant contact for information directed to the eligibility questionnaire. The online software QuestionPro (2019) and Appointlet (2019) were used to determine eligibility and schedule study times for participants (See Appendix B). When a potential participant completed the eligibility questionnaire via QuestionPro, they were redirected to Appointlet.com, where they scheduled their appointment time. All participants were compensated with a \$15 gift card.

Data were collected from 71 participants, however, due to technical errors and drop-outs, complete inhibitory ability data was only obtained from 57 and complete fNIRS data from 48 (see Figure 3.1). Of the 57, the majority were male (54.4%) and Hispanic (73.7%). Ages ranged

from 18 to 50 and the average age was 31.3 (SD = 8.77). Most reported having at least a high school education (98.2%).

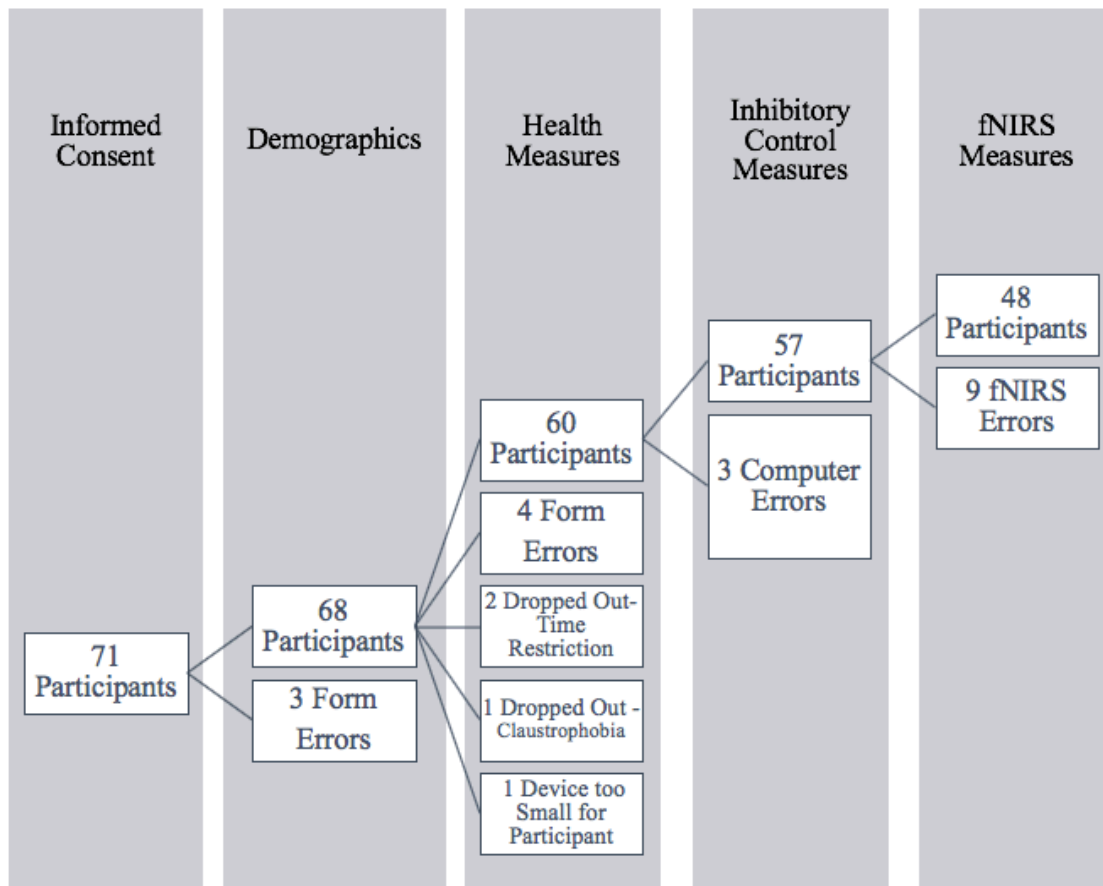


Figure 3.1: Decomposition of Participants, Errors, and Drop-outs

The majority of participants reported on the demographical questionnaire (see Appendix C) that their primary language was English (68.4%) and on a scale of 1 to 5, they indicated having good to excellent self-rated proficiency (M = 4.8, SD = .54)<sup>1</sup>. Self-rated Spanish language ability was rated as good (Mean = 3.8, SD = 1.36). Two participants reported being English monolinguals. While 24.6% indicated that they had below proficient ability in Spanish.

<sup>1</sup> Language proficiency was surveyed using very basic methods (see Appendix C). True language proficiency would require more time and were not of primary interest in the current study. Socioeconomic status was calculated based on education, employment, and income (Oakes &

Rossi, 2003; Saleem, 2018). The bulk of the group was categorized as middle-class (67.34%).

## **Materials**

### **CUED GO/NO-GO TASK**

Response restraint inhibitory control ability was measured using the cued Go/No-go task (Fillmore, Rush, & Hays, 2006). The task was programmed using Inquisit 5 software (Inquisit 5, 2016). Participants were asked to press the spacebar when a green rectangle appears (Go trial) on the screen and to refrain from pressing the spacebar when a blue rectangle appears (No-go trial) (see Figure 3.2). The rectangles could appear in both horizontal and vertical positions and before the color of the rectangle appears, a cue appeared showing the position of the following stimulus. Vertical rectangles have a high probability (4:1) of being a go trial where horizontal rectangles have a low probability (1:4) of being a go trial.

Each trial consisted of a fixation point for 800ms, then a 500ms white screen, followed by a cue displayed for one of five stimulus onset asynchronies (100, 200, 300, 400, or 500ms) then a go or no-go target. The target then remained until a response or 1000ms had occurred. Between each trial was a 700ms interval. The task consisted of 250 trials; 100 vertical cue go targets; 25 vertical cue no-go targets; 100 horizontal cue no-go targets; and 25 horizontal cue go targets.

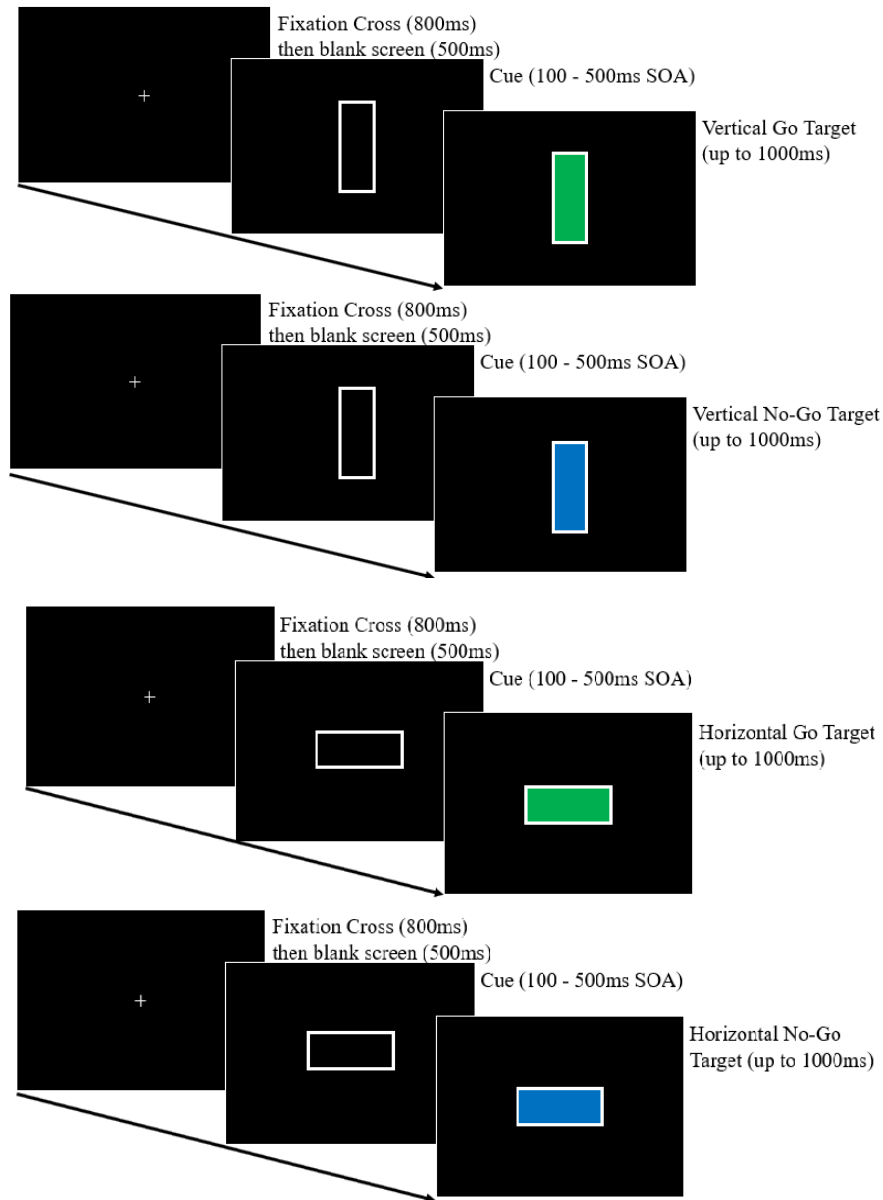


Figure 3.2: Cued Go/No-go Task Design

The proportion of inhibition errors made during the task was calculated by dividing the number of trials where participants responded to a no-go stimulus. Error rates were calculated for both cue conditions (vertical and horizontal). Mean reaction times were also calculated for all go trials, vertical go trials, and horizontal go trials. The primary indicator of response restraint ability was defined as the error rate on no-go trials and error rates on vertical no-go trials. Since

vertical cue trials produce a stronger prepotent go response, no-go inhibition errors on these trials are more indicative of response restraint performance.

### **STOP SIGNAL TASK**

The stop signal task paradigm (Logan, 1994) was used to measure response cancellation inhibitory control ability. The task was programmed using Inquisit 5 software (Inquisit 5, 2016). The task consisted of a blank screen that first displayed a circle containing a left or right-pointing arrow. The participant was instructed to press the key which corresponds with the arrow direction (d for left, k for right), unless a tone is played, indicating not to respond. The delay between the arrow stimulus and the tone begins at 250ms and then is increased or decreased by 50ms depending on the prior trial performance. The maximum delay was 1150ms and the minimum 50ms, with responding allowed up until the beginning of the next trial (see Figure 3.3). There was a stimulus onset asynchrony of 2000ms before the start of each trial. The task consisted of 1 practice block of 32 trials including 8 stop tone (stop signal) trials and 24 no tone trials. The test proportion of the task consisted of three blocks, each with 64 trials with the same 1:3 proportion of stop signal to non-stop signal trials.

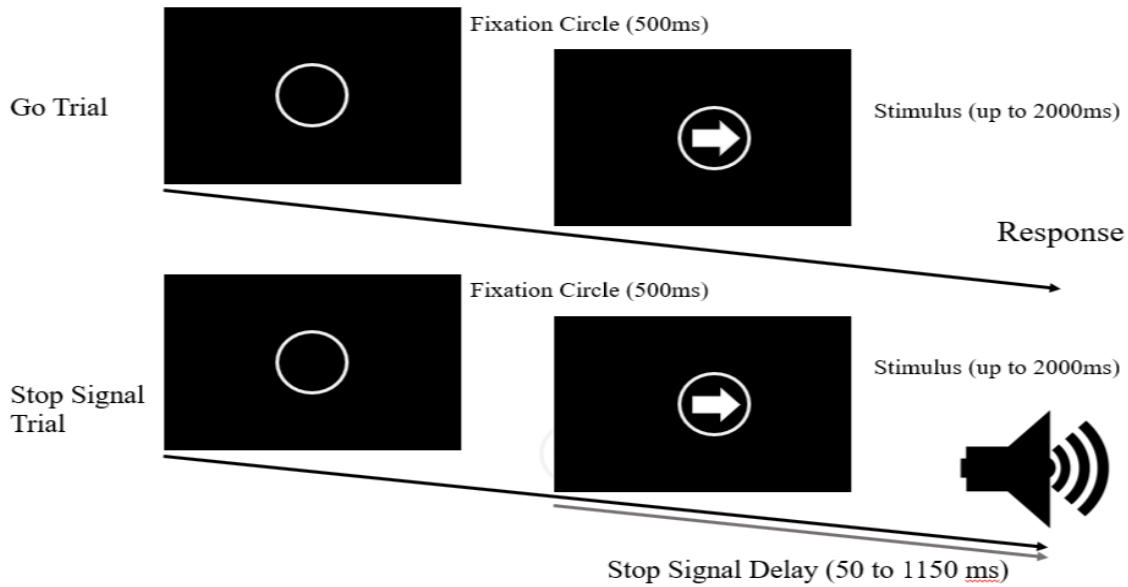


Figure 3.3: Stop Signal Task Design

Participants' percentage of hits, misses, and mean reaction time were calculated for non-stop signal trials. The probability of reacting in a stop-signal trial was calculated. The primary indicator of response cancellation ability was defined as stop signal reaction estimated time. This is the estimated time required to stop the initiated go-process which was calculated using the subtraction method established by Verbruggen, Chambers, and Logan (2013).

## Apparatus

### ANTHROPOMORPHIC MEASUREMENTS

We measured waist and hip circumferences using an anthropometric tape calculator waist-to-hip ratio as  $[\text{waist circumference (cm)} / \text{hip circumference (cm)}]$ . Females with waist-to-hip ratios greater than .85 and men who were greater than .90 are considered to have abdominal obesity (World Health Organization, 2011). Height and weight were obtained using a calibrated portable stadiometer and scale connected to a Bod Pod air displacement plethysmography system (Life Measurement Inc., Concord, California, USA). Body mass index was calculated as  $[\text{weight (kg)} / \text{height (m)}^2]$ . Participants with body mass index values greater than 25 are considered



overweight and greater than 30 obese (World Health Organization, 2017). We determined body fat percentage using a Bod Pod air displacement plethysmography system (Life Measurement Inc., Concord, California, USA). When considering body fat percentage, the following categorization was used to classify individuals as overweight/obese according to their age and body fat percentage: men ages 18-39 who had more than 20% body fat, men ages 40-50 who had more than 22% body fat, women ages 18-39 who had more than 33% body fat, and women ages 40-59 who had more than 34% body fat are considered as overweight/obese (Gallagher et al., 2000).

#### **ARTERIAL STIFFNESS**

A SphygmoCor EM3 pulse wave velocity system and connected laptop (AtCor Medical Pty. Ltd., Sydney, Australia) were used to measure carotid-femoral pulse wave velocity. carotid-femoral pulse wave velocity is the gold standard for measuring arterial stiffness (Van Bortel et al., 2012). A connected pressure tonometer recorded pressure pulse waveforms while the system recorded ECG signals. The system calculated the carotid-femoral pulse wave velocity using the mean time difference and length between the two measurement sites (AtCor Medical Pty. Ltd., 2000).

#### **PRE-FRONTAL CORTEX HEMODYNAMIC RESPONSE**

A continuous-wave function near-infrared optical brain imaging unit fNIRS100, 16 channel sensor array (BIOPAC Systems, Inc.; [www.biopac.com](http://www.biopac.com)), and a laptop computer were used to collect hemodynamic response data. The fNIRS100 was controlled using Cognitive Optical Brain Imaging (COBI) Studio software (Ayaz, 2005). The connected fNIRS sensor array consisted of four IR light sources (both 730 and 850 nm wavelengths) and ten light detectors mounted within a headband placed on the forehead. The fNIRS100 device calculates the relative

levels of HbO<sub>2</sub> and HHb based upon local baseline levels based upon the modified Beer-Lambert law (Ayaz, 2005). The desktop and the laptop were connected with a serial cable so that Inquisit 5 was able to send electronic triggers and markers to COBI studio allowing for task automation and fNIRS data analysis. Task programming sent unique markers via serial cable to the fNIRS data collection software, COBI, at the beginning and end of the practice and test blocks. The markers allowed for analysis of the hemodynamic response for each task.

Functional Near-Infrared Spectroscopy data were processed using FNIRSOFT v4.3 (Ayaz, 2010). Each raw light data file had electronic noise, ambient light, and motion artifacts removed (Ayaz, 2010). Raw light data files were cleaned by applying a programmed script which first applied a finite impulse response (FIR) digital filter, then an ambient light filter, and finally a sliding-window motion artifact rejection (SMAR) filter (see Appendix E). Refined light data was then used to calculate oxygenated (HBO<sub>2</sub>) and deoxygenated (HHR) by applying the modified beer Lambert law (MBLL) and using baseline light data collected at the beginning of each task.

Next, oxygenation data files were processed using a detrending filter. This filter accounts for global signal drift commonly seen in fNIRS data (Ayaz, 2010). Next, the oxygenation data was processed with a Correlation Based Signal Improvement (CBSI) algorithm to reduce noise based on the principle that oxyhemoglobin and deoxyhemoglobin levels are negatively correlated (Cui, Bray, & Reiss, 2010). These filters were applied using a programmed script and overall improved signal quality and reduce noise leading to more correct hemodynamic data to be extracted (Appendix E).

Next, the task blocks were defined using the markers which were sent from Inquisit 5. Automation techniques in FNIRSoft (Ayaz, 2010) allowed for the extraction of 4 total blocks

being defined (three blocks for the Stop-Signal Task, and one overall block for Go/No-go task). Then, mean oxygenated hemoglobin (were extracted from each task using a programmed script (Appendix E). Since forehead size and hair/eyebrow position varies the programmed script automatically trimmed data to the four middle voxels (see Illustration 3.1). Each block had oxygenated hemoglobin (HbO<sub>2</sub>) and deoxygenated hemoglobin (HHb) extracted. Brain hemodynamic response as measured by fNIRS levels of HHb has a well-established relationship with the functional magnetic resonance imaging (fMRI) blood-oxygenation-level dependent (BOLD) signal (Strangman, Culver, Thompson, & Boas, 2002). However, more recent work has indicated that the levels of HbO<sub>2</sub> better reflect hemodynamics response during function tasks with a better noise to signal ratio than the level of HHb (Huppert, Hoge, Diamond, Franceschini, & Boas, 2006; Strangman, Franceschini, & Boas, 2003). Our main outcome for the hemodynamic response during the tasks was the mean level of HbO<sub>2</sub> in the left and right PFC.

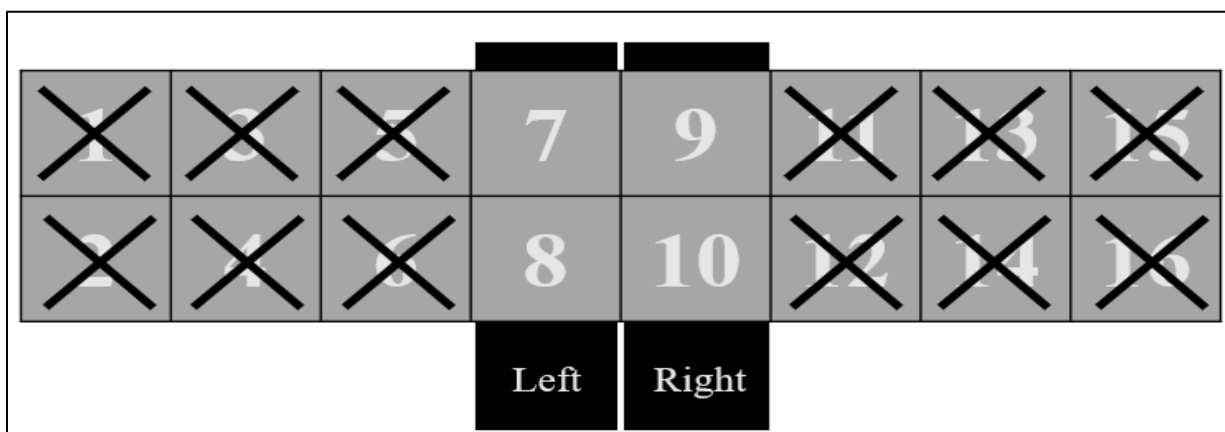


Illustration 3.1: fNIRS Sensor Layout and Regions Excused.

## Procedure

The Institutional Review Board (IRB) approved all materials and procedures. All researchers completed IRB required training and were trained and tested on all measurement techniques before data collection. Parking was provided to participants on campus, however,

parking was changed to decrease distance participants had to walk to the laboratory (10-minute walk), time to find parking (30-45 minutes), and to overall decrease the total time to complete the study. During the initial part of the experiment, two participants had to discontinue participation without completion due to the time constraints of their next commitment (i.e. work).

On arrival to the laboratory, participants were seated to read and completed informed consent (see Appendix D). Next, they completed a brief questionnaire hosted via QuestionPro on an iPad. The researcher instructed the participant to remain seated after completion of the questionnaire.

All health measurements were recorded by the researcher using QuestionPro (Appendix D) on an iPad or paper form. First, the researcher measured their blood pressure and pulse rate using an OMRON 5 Series Upper Arm Blood Pressure Monitor. Then participants were instructed to remove their shoes, any items on their heads, and remove any items or bulky clothing from their person (e.g. phones, belt, jewelry, jackets, coats).

Next participants' height, waist circumference, and hip circumference were measured following guidelines from the World Health Organization (2011). The participant was instructed to stand upright with feet slightly apart and arms to the side loosely hanging while the researcher was seated on a chair slightly to one side of the participant. Waist circumference was measured at the minimum circumference between the iliac crest and the rib cage and timed at which the subject is exhaling. Next, the hip circumference was measured at the maximum width over the greater trochanters (see Illustration 3.2).

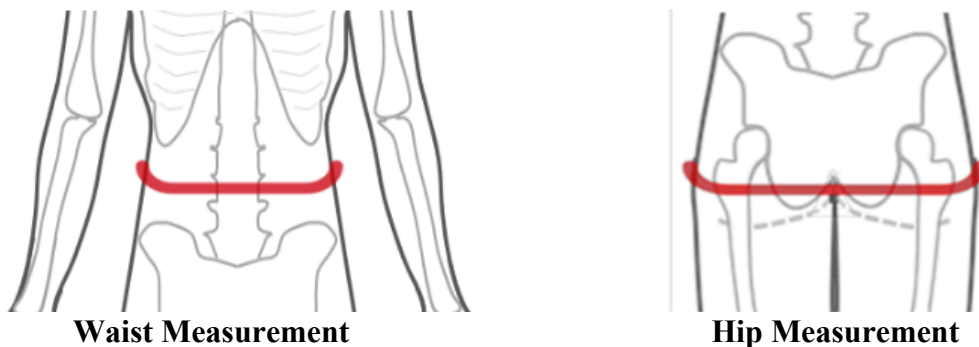


Illustration 3.2: Waist and hip Measurements for Waist-to-hip Ratio Calculation.

*Note.* Adapted from World Health Organization (2011).

Participant body weight and body fat percentage were measured using the Bod Pod (Life Measurement Inc., Concord, California, USA). The Bod Pod software was used to predict participants' lung volume. One participant discontinued the study of the worry that the Bod Pod's confined enclosure would provoke their claustrophobia.

#### **PULSE WAVE VELOCITY**

Next, participants were instructed to lie down on an exam table face up, and a 5-minute timer started. Then the disposable ECG electrodes were placed on the participants' left and right wrists and left ankle. The SphygmoCor EM3 was then connected to the electrodes and pulse wave velocity was measured following the manufacturer's guidelines (AtCor Medical Pty Ltd, 2000). First, the researcher input the participant's age, height, and blood pressure into the software. Then the participant was instructed to extend their neck and slightly lift their chin while turning the head away to the left. The researcher located the carotid artery then measured from the suprasternal notch to the aortic pulse site. The researcher located the femoral artery and measure from the suprasternal notch to the femoral pulse site (see Illustration 3.3). These measurements were then inputted into the SphygmoCor software.

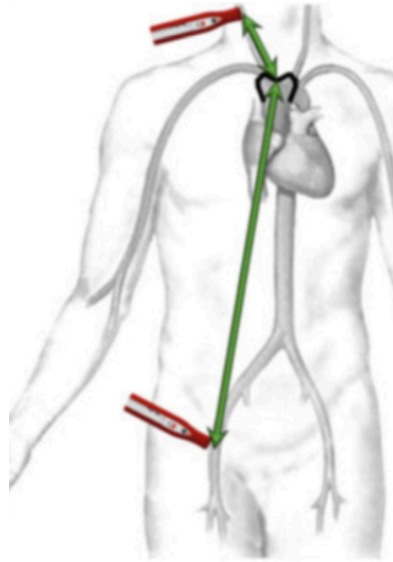


Illustration 3.3: Measurement of Aortic and Femoral Distances for Pulse Wave Velocity.

*Note.* Adapted from AtCor Medical Pty Ltd. (2000).

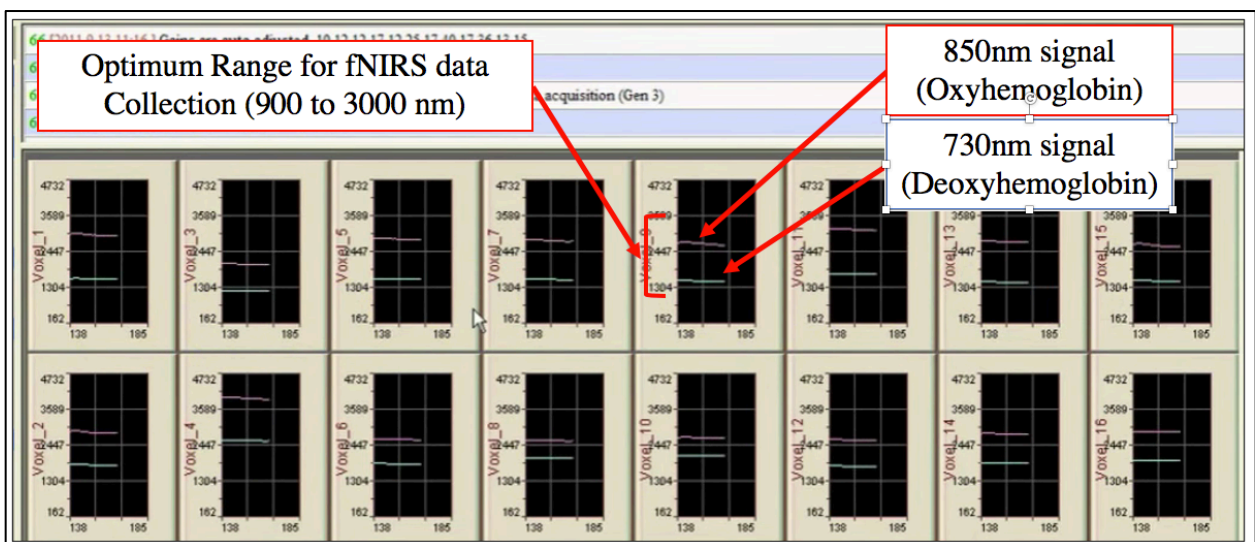
Once the 5-minute timer had expired, PWV measurement was started. First, the researcher used the tonometer to probe the carotid artery site. Once found, the researcher held the position for a minimum of 20 seconds while the measurement was collected checking the quality of waveforms (see Illustration 3.4). Then the researcher located the femoral pulse site and used the same procedure. The software computes the time it takes for the pulse to travel for both sites using the ECG and tonometer data then automaticity computes pulse wave velocity and the error associated with the measurement. To ensure accuracy, the researcher took a second PWV measurement, if the confidence intervals from the 1<sup>st</sup> and 2<sup>nd</sup> measurement did not overlap, a third measurement was obtained. The mean of these measurements was used as the participant's overall PWV. One participant could not complete the measurement of blood pressure or pulse wave velocity as the device could not fit due to the thickness of the participant's arm/leg.



Illustration 3.4: Proper Measurement for Pulse Wave Velocity.

*Note.* Adapted from AtCor Medical Pty Ltd. (2000).

Participants were sat at a table with a desktop computer and were fitted with the fNIRS headband making sure that there is no hair under the sensor array and that the sensor is centered with the midline of the face. The window blinds were closed, and the lights turned off to reduce ambient light interference. Next, the researcher adjusted the sensor LED gain to get data in levels in optimal ranges (Figure 3.5) (Ayaz, 2010).



### Illustration 3.5: fNIRS Data for the 16 Area Sensor Array

*Note.* Adapted from Ayaz (2000).

Next, the testing procedure was started on the desktop computer. At the beginning of each task, the researcher verbally explained the task. The neuroimaging procedure was automated. Once the fNIRS device was turned on, triggers in the Inquisit programming would signal COBI studio to take baseline and begin recording. The baseline procedure was programmed using Inquisit 5. This procedure consisted of a screen which instructed participants to prepare by being calm and following the computer by taking three deep breaths. For each breath, the participant was guided by three consecutive 1000ms screens with “Inhale 1,2,3” followed by three consecutive 1000ms screens with “Exhale 1,2,3”. After the three breaths, a fixation point appeared, and a trigger was sent to the fNIRS device to begin the 8000ms baseline recording.

The order of the tasks was counterbalanced so that half of the participants completed the Go/No-go task first while the others completed the Stop-Signal task first. Before each task, the baseline procedure was performed. Once the testing procedure had been completed the researcher stopped fNIRS recording, finalized the data, and removed the sensor from the participant's forehead. Researcher errors during finalization caused COBI studio to not save hemodynamic data for 10 participants. Likewise, technical issues with Inquisit 5 led to corrupt data for 1 participant's data file. Lastly, the participant was debriefed and provided their monetary incentive.

### **DATA CLEANING**

A systematic approach was followed to ensure data quality. First, all health variables were inspected for values that were out of range for the physiological measurement. If a value indicated some error in measurement it was marked as missing. Pulse wave velocity (9.7 m/s) for



one participant was removed because it fell outside of the 95% confidence interval for their age (30) and gender (male) (Enticott, Ogloff, & Bradshaw, 2006; Mitchell et al, 2004). Next, performance data from the inhibitory control tasks were examined for high error rates ( $> 70\%$ ) which indicated miscommunication of instructions or lack of following directions similar to common practices in cognitive research (Clark, 2019, Feest, Harwood, & Falcone, 2019; Van Wouwe, Claassen, Neimat, Kanoff, & Wylie, 2017). We removed 4 participants' Cued Go/No-go task performance and 1 participant's stop-signal task performance.

## **STATISTICAL ANALYSIS**

We conducted the analysis using SPSS (v26). First, we extracted basic statistics to characterize the sample, task performance, and hemodynamic response. Independent sample t-tests were conducted to determine if there was a influence of task counterbalance order on performance and hemodynamic variables. Next, Pearson correlation coefficients were calculated between our variables of interest. Finally, hierarchical multiple linear regressions were used to initially control for the influence of age, socioeconomic status, and body fat percentage. In the next step of the hierarchical regression, pulse wave velocity was added to the model to determine its incremental validity. Finally, the mean left and right levels of oxygenated hemoglobin were added in the last step of the model to explain additional variance in performance on the response inhibition tasks. This three-step hierarchical multiple regression was conducted to predict the two primary outcome variables (vertical cue no-go error rate and stop-signal reaction time).

## CHAPTER 4: RESULTS

### Anthropomorphic Characteristics and Arterial Stiffness

Most of the sample was considered non-lean (overweight/obese) when taking into account waist-to-hip ratio, body mass index, and body fat percentage (see Table 4.1). With body mass index, 17.5% were overweight, while 50.9% were obese. Based on waist-to-hip ratio, over half had adnominal obesity and had body fat percentage which placed them in the non-lean range. No significant differences were found between females or males for waist-to-hip ratio or body mass index. Females had significantly more body fat as compared to males,  $t(55) = 2.457$ ,  $d = .65$ ,  $p = .017$ .

Table 4.1: Sample Anthropomorphic Characteristics

Adiposity Indices	Females ( $n = 26$ )		Males ( $n = 31$ )		Total Percentage Non-lean
	Mean (SD)	Range	Mean (SD)	Range	
Waist-to-Hip Ratio	0.86 (0.12)	.61 – 1.22	0.92 (0.08)	.81 – 1.16	52.63%
Body Mass Index	29.06 (6.5)	19.1 - 42.13	29.34 (6.0)	18.04 – 29.34	68.4%
Body Fat Percentage	30.01 (11.2)	8 - 50.2	23.62 (8.4)	8.6 – 42.4	52.63%

*Note.* Non-lean ranges for adiposity indices were based on standards from the WHO (2011, 2017) and Gallagher et al., (2000).

Aortic-femoral pulse wave velocity ranged from 3.30 to 8.25 meter/second(m/s) and on average was 5.76 m/s ( $SD = 1.06$ ). Females had significantly lower pulse wave velocities than males,  $t(54) = -2.043$ ,  $d = .54$ ,  $p = .046$ . Pearson correlations revealed positive association

between increased pulse wave velocity and waist-to-hip ratio,  $r(57) = .569, p = .044$ , body mass index,  $r(57) = .360, p = .006$ , but not body fat percentage,  $r(57) = .232, p = .085$ .

### Cued Go/No-go Task

Performance on the Cued Go/No-go task was very accurate (<1% error rate) and had little variability (see Table 4.2). Participants made little to no errors on both vertical and horizontal cue trial types. Mean inhibition errors did not statistically differ between horizontal or vertical cue trials. Mean go trial error rates did not statistically differ between vertical cue and horizontal cue trials. Mean reaction time for horizontal cues trials were significantly slower than vertical cue trials,  $d = .22, p < .001$ . There was no significant effect of task counterbalance order on any outcomes,  $p > .05$ .

Table 4.2: Mean Cued Go/No-go Performance ( $n = 53$ )

	All Trials	Vertical Cue Trials	Horizontal Cue Trials	t-test for Cue Diff.	
	Mean (SD)	Mean (SD)	Mean (SD)	<i>t</i>	<i>p</i>
Total Error Rate	.0072 (.015)	.0074 (.019)	.0071 (.013)	.20	.84
Inhibition Errors	.0078 (.025)	.0083 (.020)	.0106 (.045)	-.85	.40
Go Trial Errors	.0066 (.010)	.0072 (.021)	.0062 (.008)	.71	.48
Go Trial RT	372 (40.03)	370 (41.11)	381 (38.47)	-4.81	.000

*Note.* Inhibition Error = Responding to a No-Go Trial; RT = Reaction Time

Results from fNIRS monitoring during the Go/No-go task revealed that the mean levels of hemoglobin were similar in the left and right PFC (see Figure 4.1). Both left oxygenated hemoglobin ( $M = .034, SD = .11$ ) [HbO<sub>2</sub>] and deoxyhemoglobin ( $M = .034, SD = .11$ ) [HHb] were significantly different from baseline;  $t(46) = 2.125, d = .28, p = .039, t(46) = -2.021, d = -$

.27,  $p = .049$ . However, there were no significant correlations between mean levels of PFC hemoglobin and any Go/No-go performance outcomes,  $p > .05$ . Additionally, there was no significant effect of task counterbalance order nor was of fNIRS sensor used on hemodynamics outcomes,  $p > .05$ .

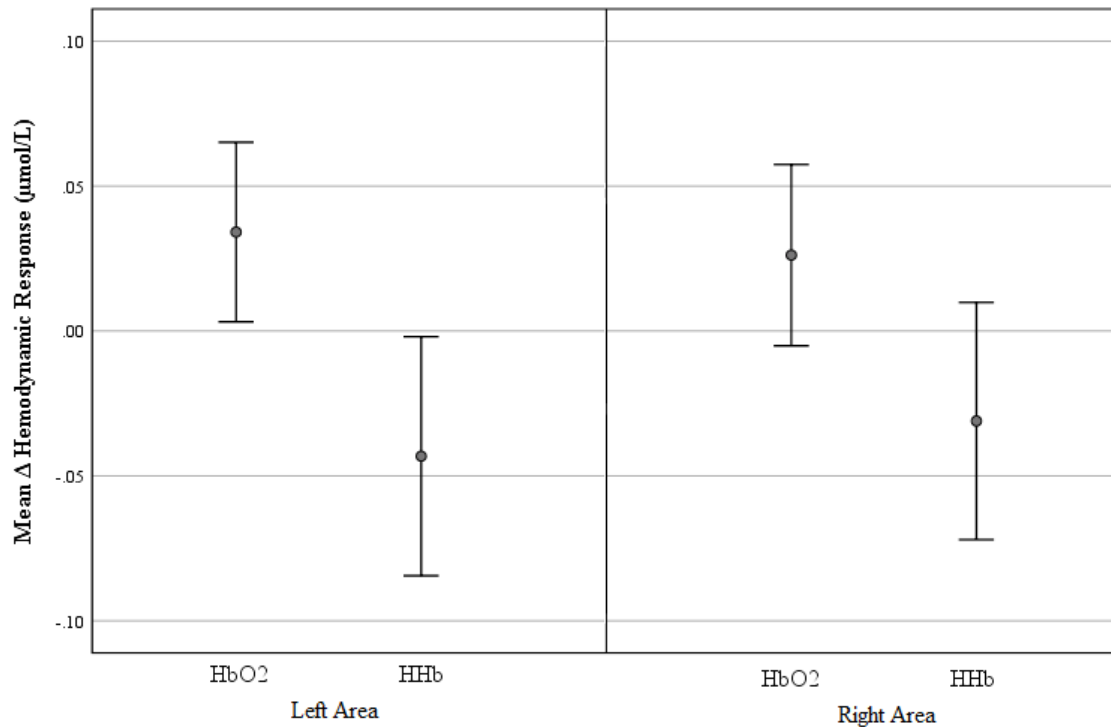


Figure 4.1: Mean Left / Right PFC Hemoglobin Levels during Go/No-go Task ( $n = 44$ )

*Note.* Error Bars Represent 95% Confidence Interval Around Mean

Cued Go/No-go task vertical no-go error rate was not significantly correlated with waist-to-hip ratios, body mass index, or body fat percentage (see Table 4.3). It was also found that the vertical no-go error rate was negatively associated with pulse wave velocity (see Table 4.3). Reaction times for both vertical and horizontal cue go trials were not significantly correlated with any of the adiposity neither pulse wave velocity (see Figure 4.2).

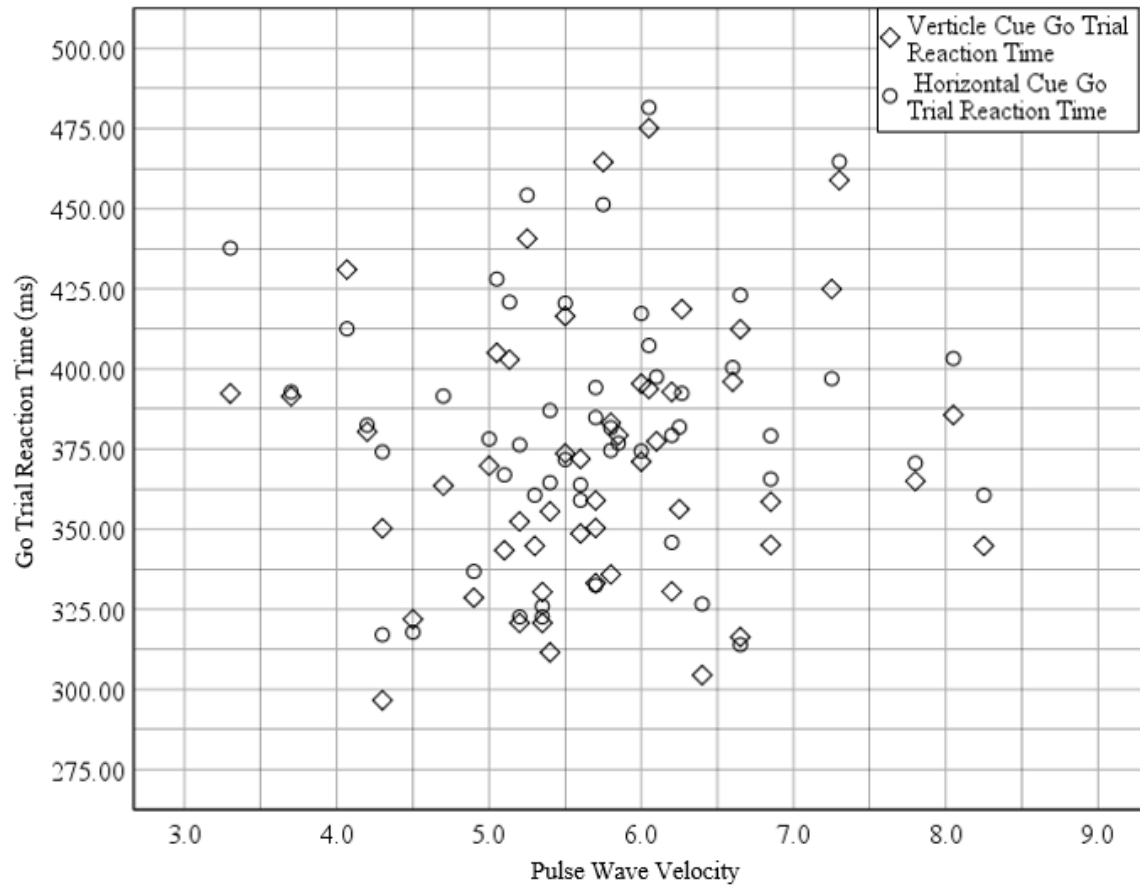


Figure 4.2: Go Trial Reaction Times and Pulse Wave Velocity

When considering PFC hemodynamic response during the Go/No-go task, Pearson correlations revealed significant associations with waist-to-hip ratio and pulse wave velocity (see Table 4.3). A greater waist-to-hip ratio was associated with lower mean levels of HbO<sub>2</sub> in the left frontal area (see Figure 4.3). The associations between pulse wave velocity and mean change in HbO<sub>2</sub> followed a similar pattern. Pearson correlations revealed that higher pulse wave velocity was associated with lower HbO<sub>2</sub> in both left and right areas of the PFC (see Figure 4.3). Mean reaction times for the Go trials were not significantly correlated to any of the adiposity indices nor pulse wave velocity for either vertical cue or horizontal cue trials (see Figure 4.4).

Table 4.3: Pearson correlations between Cued Go/No-go Task, Mean PFC Hemoglobin Levels, Anthropomorphic Characteristics, and Arterial Stiffness.

	Vertical No-Go Error Rate ( $n = 53$ )	Mean PFC Hemoglobin Levels ( $n = 44$ )	
		Left HbO2	Right HbO2
Waist-to-Hip Ratio	-.173	-.348*	-.272
Body Mass Index	-.087	-.145	-.151
Body Fat Percentage	-.086	-.007	-.034
Pulse Wave Velocity	-.325*	-.372*	-.272

Note: PFC = Prefrontal Cortex; HbO2 = Oxygenated hemoglobin; \* $p < .05$ ; \*\* $p < .01$

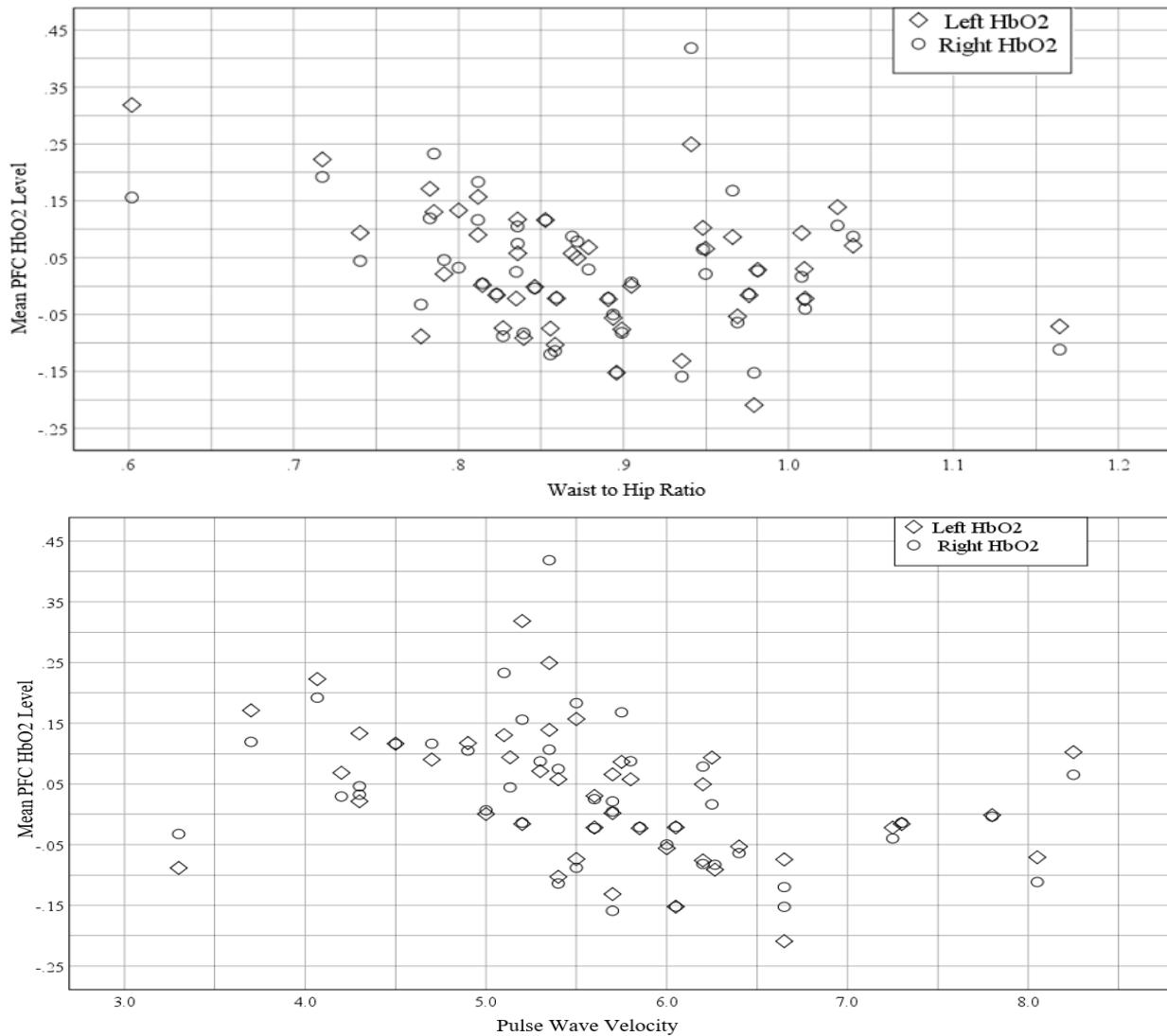


Figure 4.3: Go/No-go PFC HbO2 with Waist-to-Hip Ratio and Pulse Wave Velocity

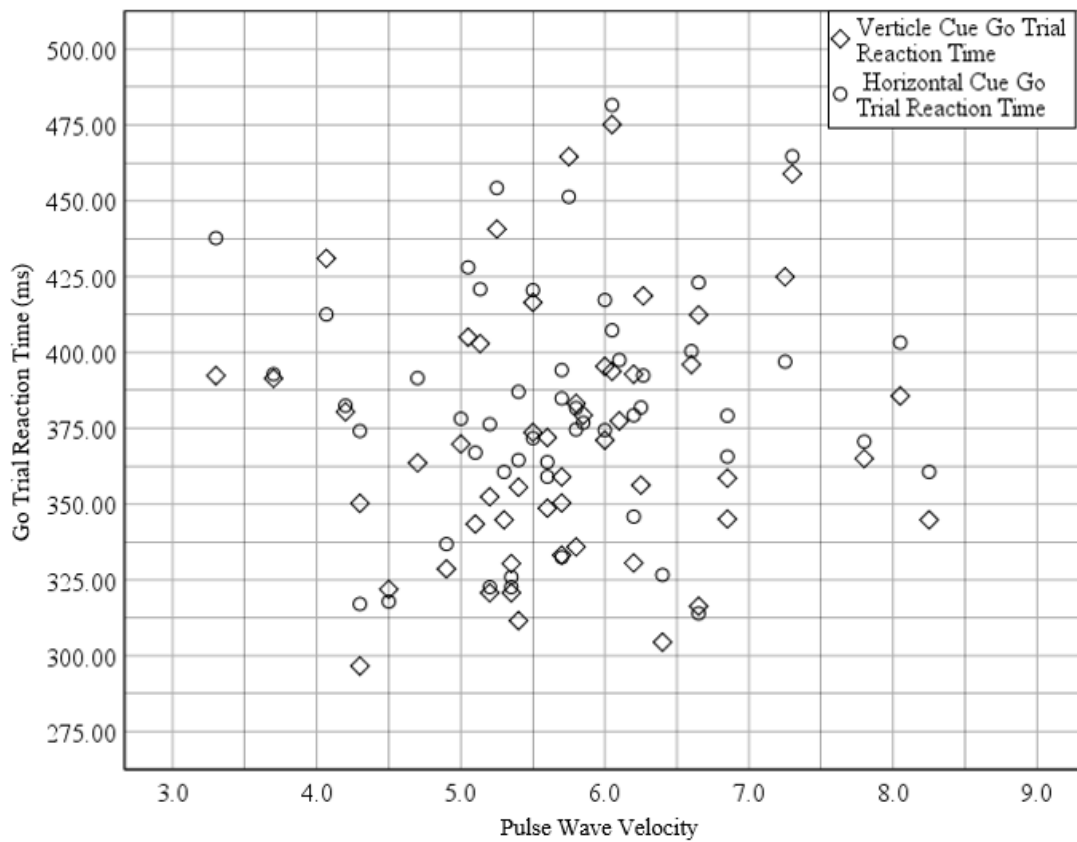


Figure 4.4: Pulse Wave Velocity and Mean Go/No-go PFC HbO2 Levels

The results of the hierarchical regression predicting Go/No-go vertical cue trial no-go error rates revealed that the addition of pulse wave velocity did not significantly increase variance explained (see Table 4.4). Similarly, the addition of mean PFC HbO2 left and right levels were able to explain a significant increase in variance explained. Overall the models were also insignificant for HbO2,  $R^2 = .167$ ,  $F(6, 43) = 1.239$ ,  $p = .309$

Table 4.4: Hierarchical Regression Results for Go/No-go Task ( $n = 44$ )

Variable	$\Delta R^2$	B	SE	95% CI		$\beta$	p-value
				LLCI	ULCI		
Step 1	0.034						
Age		.00026	.0003	-0.001	0.001	0.341	0.160
Socioeconomic Status		.00004	.001	-0.003	0.003	0.874	0.395
Body Fat Percent		.00007	.0003	-0.001	0.001	0.736	0.206
Step 2	0.075						
Pulse Wave Velocity		-.007	.003	-0.015	0.001	-0.292	0.078
Step 3	0.058						
Left Mean HbO2		-0.127	.062	-0.287	0.033	-0.533	0.117
Right Mean HbO2		0.100	.059	-0.051	0.252	0.442	0.189

*Note.* CI = Confidence Interval; LL = Lower Limit; UL = Upper Limit; SE = Standard Error;

\* $p < .05$ ; HbO2 = Oxygenated hemoglobin

### Stop Signal Task

Participant performance on the Stop Signal task was overall accurate (see Table 4.5). Stop signal trials had a more varied performance as compared to non-stop signal trials. There was no significant effect of task counterbalance order,  $p > .05$ . During the Stop Signal task, the mean levels of hemoglobin were similar in the left and right frontal areas (See Figure 4.5). Left area mean HbO2 ( $M = .062$ ,  $SD = .194$ ) was significantly different from baseline;  $t(47) = 2.15$ ,  $d = .32$ ,  $p = .032$ . No significant correlations were found between mean levels of PFC hemoglobin and any stop signal outcomes,  $p > .05$ . Additionally, there was no significant effect of task counterbalance order nor was of fNIRS sensor used on hemodynamics outcomes,  $p > .05$ .

Table 4.5: Mean Stop Signal Task Performance ( $n = 56$ )

Trial Type	Mean (SD)	Range
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Non-stop Signal Trials	Hits	95.29 (6.82)	65.5 - 100
	Misses	3.93 (5.50)	0 - 27.47
	Reaction time (ms)	753.36 (169.53)	376 - 1089.44
Stop Signal Trials	Probability of Response	44.57 (11.86)	31.25 - 97.87
	Stop Signal Delay (ms)	521.85 (206.89)	52.13 - 911.70
	Stop Signal Reaction Time (ms) [SSRT]	231.97 (63.25)	99.97 - 231.97

*Note.* ms = milliseconds; SSRT computed using subtraction method (Verbruggen, Chambers & Logan, 2013)

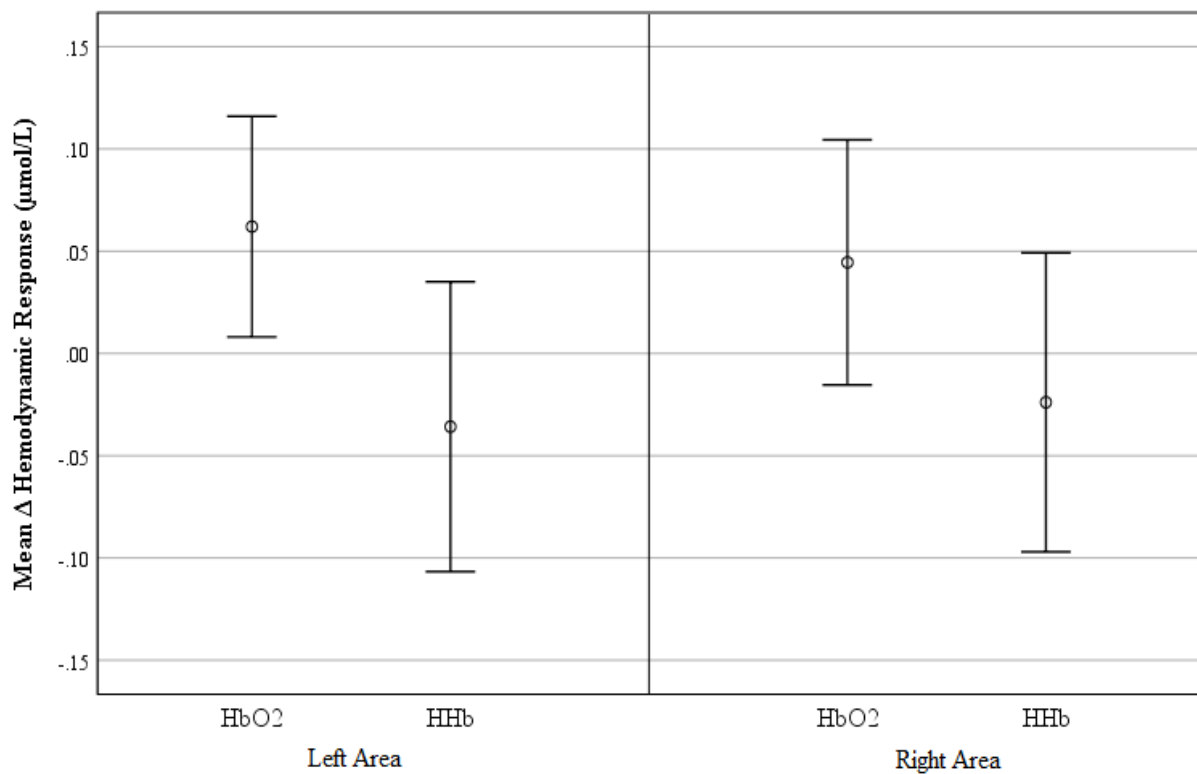


Figure 4.5: Left / Right Mean PFC Hemoglobin Levels during Stop Signal Task ( $n = 47$ )

*Note.* Error Bars Represent 95% Confidence Interval Around Mean

Pearson correlations revealed that waist-to-hip ratio and pulse wave velocity were significantly associated with stop signal performance (see Table 4.6). Greater waist-to-hip ratio

and pulse wave velocity were significantly associated with longer stop-signal reaction time,  $r = .40$ ,  $p < .05$  (see Figure 4.6).

Table 4.6: Pearson correlations between Stop Signal Task, Mean Oxyhemoglobin Levels, Anthropomorphic Characteristics, and Arterial Stiffness.

	Stop Signal Reaction Time ( $n=56$ )	Mean PFC Hemoglobin ( $n=47$ )	
		Left HbO2	Right HbO2
Waist-to-Hip Ratio	.469**	.112	.244
Body Mass Index	.178	-.194	-.308*
Body Fat Percentage	.240	-.103	-.288*
Pulse Wave Velocity	.400**	.138	.198

*Note.* PFC = Prefrontal Cortex; HbO2 = Oxygenated hemoglobin; \* $p < .05$ ; \*\* $p < .01$

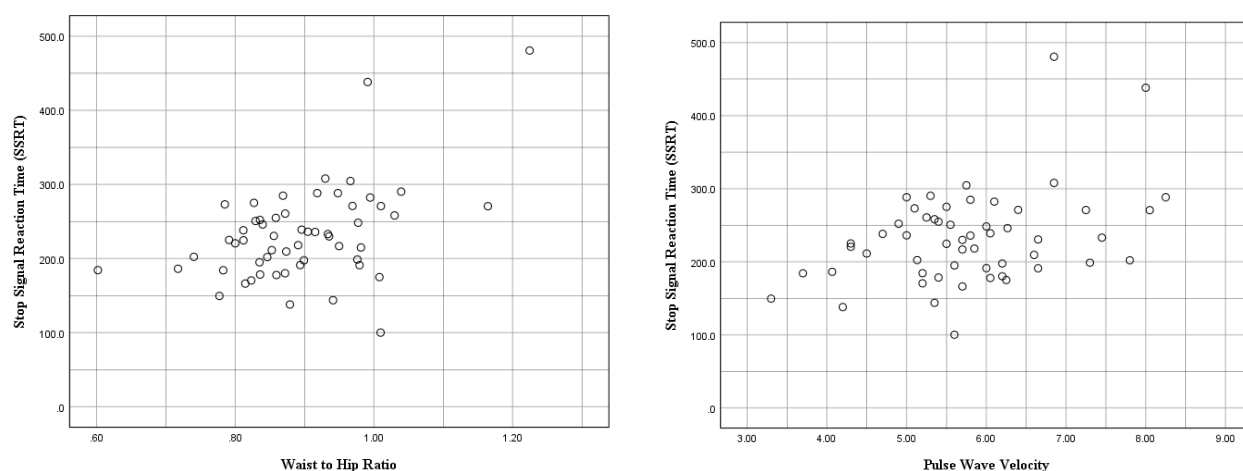


Figure 4.6: Stop Signal Reaction Times, Waist-to-Hip Ratio, and Pulse Wave Velocity

Considering the mean level of hemoglobin during the Stop Signal task, Pearson correlations revealed associations with body mass index and body fat percentage. A greater body mass index was associated with a lower mean right PFC HbO2 level during the stop-signal task,  $r = -.308$ ,  $p < .05$  (see Figure 4.7). A similar relationship was found with body fat percentage, greater body fat percentage was associated with lower mean right PFC HbO2 level during the stop-signal task,  $r = -.288$ ,  $p < .05$  (see Figure 4.7).

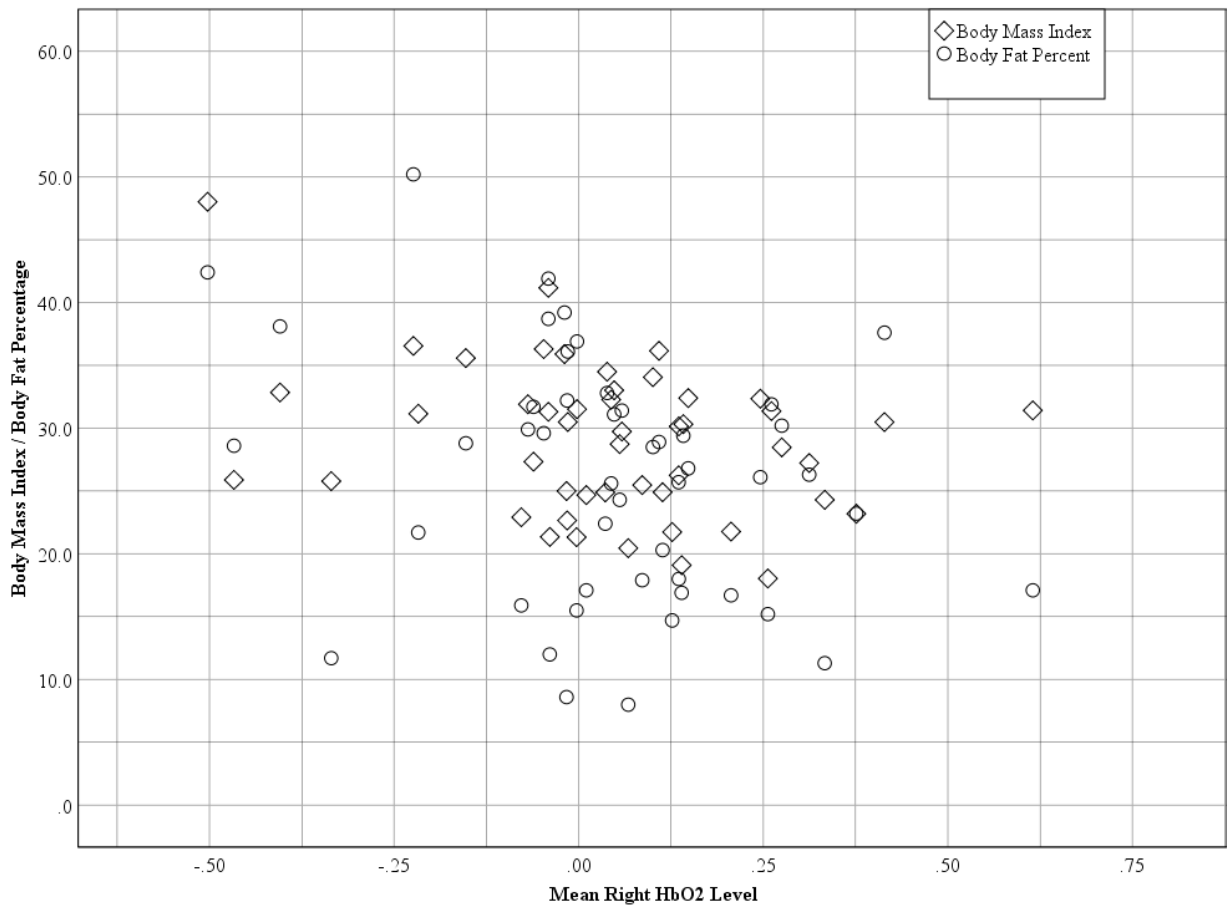


Figure 4.7: BMI and Body Fat Percentage with Right Mean PFC HbO2 Levels during Stop Signal Task

The results of the hierarchical regression predicting stop signal reaction time did reveal that the addition of pulse wave velocity significantly increased variance explained (see Table 4.7). The addition of mean levels of HbO2 in step 3 did not explain significant more variance.

Still, the overall model which included all variables were significant,  $R^2 = .301$ ,  $F(6, 46) = 2.875$ ,  $p = .020$ .

Table 4.7: Hierarchical Regression Results for Stop Signal Task ( $n = 47$ )

Variable	$\Delta R^2$	B	SE	95% CI		$\beta$	p-value
				LLCI	ULCI		
Step 1	0.131						
Age		1.333	.933	-0.549	3.216	0.218	0.160
Socioeconomic Status		-2.280	2.654	-7.633	3.072	-0.128	0.395
Body Fat Percent <sup>1</sup>		1.057	.823	-0.603	2.717	0.189	0.206
Step 2	0.090*						
Pulse Wave Velocity		16.091	7.31	1.347	30.834	0.325	0.033
Step 3	0.080						
Left Mean HbO2		-129.742	60.84	-18.427	171.222	-0.460	0.047
Right Mean HbO2		121.353	63.41	-156.758	33.862	0.478	0.053

Note. CI = Confidence Interval; LL = Lower Limit; UL = Upper Limit; SE = Standard Error;

\* $p < .05$ ; HbO2 = Oxygenated hemoglobin

<sup>1</sup>As a requested follow-up to this analysis, waist-to-hip ratio was exchanged for body fat percentage in step 1 of the analysis. While the proportion of explained variance increased from 13.1% to 15.2% in step one, explaining 15.2% of the variance with the three variables was not statistically significant,  $p = .227$ . In step 2, pulse wave velocity was able to increase variance explained by 7.5%, however, this change was not significantly statistical. In this analysis, pulse wave velocity increased variability explained by 7.5%,  $p = .055$ .

## CHAPTER 5: DISCUSSION

In this study, we addressed the question of whether adiposity, vascular health, and brain hemodynamic response are associated with inhibitory control ability in healthy adults. Our primary results were that; a) greater waist-to-hip ratio and pulse wave velocity were associated with poorer response cancellation ability, b) greater waist-to-hip ratio and pulse wave velocity were associated with reduced response restraint PFC hemodynamic response, c) greater body mass index and body fat percentage were associated with reduced response cancellation PFC hemodynamic response. Furthermore, we found that pulse wave velocity was able to account for significantly more variance in response cancellation score when added to a model which included age, SES, and body fat percentage.

### **Adiposity, Response Inhibition, and PFC Hemodynamics**

The observed behavioral performance on the Cued Go/No-go task indicated issues with the task design. Notably, the mean error rate for the Go/No-go task was below 1%. The extremely low amounts of errors indicate that our task design was not difficult enough to index variability in response restraint ability. Comparable results were seen by Calvo, Gunstad, and Spitznagel (2014) who used the same task and also did not find significant differences between obese and non-obese groups. Since our sample was younger and of higher socioeconomic status, a more challenging task may better index response restraint performance. Alternatively, other studies have used a modified Go/No-go task using food stimuli. In these studies, significant differences were found between normal weight and obese groups (Batterink, Yokum, & Strice, 2010; Mobbs et al., 2011; Silvers et al., 2014). Additionally, Gerdan and Kurt (2020) demonstrated that differences between normal weight and obese were not seen in Go/No-go neutral stimuli, but were evident when food stimuli were used. Likewise, these authors also

demonstrated that performance in obese individuals was also a function of the calorie content of the food stimuli.

Nevertheless, our results did show that a greater waist-to-hip ratio was associated with poorer response cancellation ability. This finding parallels findings from other studies showing differences in stop signal performance between normal weight and centrally obese adults (Karunathilaka, Hewage, Wimalasekera, & Amarasekara, 2018). However, we expected that all adiposity measures would be significantly related to response cancellation performance. Our null findings for body mass index and body fat percentage are contrary to several studies which show significant differences between obese and normal-weight groups based on BMI (Bongers et al., 2015; Hendrick et al., 2012; Lavagnino et al., 2016; Mole et al., 2014). Our findings that waist-to-hip ratio is more associated with performance add support to the literature which highlights abdominal obesity as a stronger and more sensitive predictor of cardiovascular risk and adverse effects on the brain (Iantorno, Campia, Di Daniele, Nistico, Forleo, Cardillo, & Tesauro, 2014; Lavie et al., 2014; Kurth et al., 2012).

When investigating task-related hemodynamic response, some indices of obesity were associated with poorer hemodynamics response. Greater waist-to-hip ratio was associated with blunted prefrontal cortex hemodynamic response during the response restraint inhibition while greater body mass index and body fat percentage were associated with blunted PFC hemodynamic response during response cancellation. Again, we expected that all three indices of adiposity would be associated with poorer PFC hemodynamic response for both tasks. Neuroimaging studies do show that frontal activity is reduced in obese participants for tasks of inhibition, however, there have been few studies which focus on specifically on response restraint and response cancellation, and even fewer which do not use food-based stimuli

(Lavagnino, Arnone, Cao, Soares, & Selvaraj, 2016; Hsu, et al., 2017; Stingl et al., 2011). It is also notable that body mass index and body fat percentage were significantly related to decreased right PFC hemodynamic during the Stop Signal task. This is similar to fMRI results which demonstrated the right PFC is involved in going, stopping, and failing such as in the Stop Signal task (Chevrier, Noseworthy, & Schachar, 2007; Levy & Wagner, 2011).

### **Arterial Stiffness, Response Inhibition, and PFC Hemodynamics**

To our knowledge, this is one of the first studies to investigate the relationship of arterial stiffness, response inhibition, and PFC hemodynamic response. While pulse wave velocity may reflect the overall health of the vascular system, measuring the specific PFC hemodynamic response may reflect a better index of vascular health in the brain (Davenport, Hogan, Eskes, Longman, & Poulin, 2012). We found that greater arterial stiffness was associated with response cancellation ability and reduced hemodynamic response during the response restraint task. The literature establishes that increased arterial stiffness is associated with decreased cognitive functioning and brain structure changes (Singer et al., 2014). Increased pulse wave velocity in older adults is associated with increased altered white matter structures in the PFC and poorer executive functioning (Elias et al., 2009; Kennedy & Raz, 2009; Poels et al., 2007). A recent systematic review points out that increased arterial stiffness has a strong relationship to declines in gray matter and white matter connectivity resulting in greater loss of cognitive function later in life, especially executive control (Badji, Sabra, Bherer, Cohen-Adad, Girouard, & Gauthier, 2019). Our results add support and further findings to younger adults.

Therefore, we expected to find that greater arterial stiffness would be significantly associated with poorer response inhibition performance. Our results did indicate significant relationships between response restraint and response cancellation abilities. However, the results

from the Cued Go/No-go task demonstrated the opposite relationship as expected. Our task and index of performance, the vertical cue no-go errors, were highly influenced by lack of task difficulty, as the majority of scores were at ceiling and there was little variability. Likewise, as previously discussed with the indices of adiposity, it may be important to consider that response restraint deficits seen with individuals with obesity as specific to food-related stimuli (Batterink, Yokum, & Strice, 2010; Gerdan & Kurt, 2020; Mobbs et al., 2011; Silvers et al., 2014).

Our results reveal a significant association between poorer response cancellation ability and increased arterial stiffness. This is similar to our findings for waist-to-hip ratio, which is highly associated with vascular health, as those with abdominal obesity have increased blood pressure, altered arterial function, and structure, and increase systemic inflammation (Yukin, 2003; Panagiotakos, Pitsavos, Yannakoulia, Chrysoshoou, & Stefanadis, 2005; Singer, Trollor, Baune, Sachdev, & Smith, 2014 ). All of these factors are also associated with poorer executive functioning in older adults (Badji, Sabra, Bherer, Cohen-Adad, Girouard, & Gauthier, 2019).

The importance of arterial stiffness to response cancellation ability is further supported by results from our hierarchical regression analysis. In our hierarchical regression analysis, we observed a significant increase in variance explained above and beyond the variance explained by the age, socioeconomic status, and body fat percentage with the addition of pulse wave velocity. Pulse wave velocity was able to add 9% in variance explained. This increase in variance supports our hypothesis that pulse wave velocity is a significant factor contributing to response cancellation performance. Furthermore, this may support the idea that even in young adulthood, arterial stiffness contributes to inhibitory control.

Considering the associations between arterial stiffness and PFC hemodynamic response, our results are mixed. Pulse wave velocity was associated with PFC hemodynamic response



during the Go/No-go task however not during the Stop Signal task. This is especially difficult to understand because of the inversed relationship we found for body mass index and body fat percentage, which was associated with PFC hemodynamic response during the Stop Signal task, yet did not during the Go/No-go task. This result may indicate that task difficulty may be influencing results. Where the Go/No-go task is simple and performance is accuracy, pulse wave velocity is seen to influence the overall levels of PFC hemoglobin. The Stop Signal task is more difficult and those with increased arterial stiffness may have greater activation but poorer accuracy. Likewise, the lack of results may be from the processing methodology of PFC hemodynamic response. Furthermore, our results were not significant across all areas of the PFC. Since the current study averaged over the entire task, the influence of pulse wave velocity may be obscured. Chevrier, Noseworthy, and Schachar (2007) point out that PFC activity during the Stop Signal task is a sequence of activity that changes over the trials. Likewise, neuroimaging paradigms often use trial or stimuli related hemodynamics to explore the influence of obesity (Lavagnino, Arnone, Cao, Soares, & Selvaraj, 2016; Hsu, et al., 2017; Stingl et al., 2011).

## **Summary**

Our sample reflects national and global trends in obesity as a large percentage of the sample was considered overweight or obese (Hales, Fryar, Carroll, Freedman, & Ogden, 2018; Inoue, Qin, Poti, Sokol, & Gordon-Larsen, 2018). The concern with growing rates of unhealthy weight is the influence it has on health, especially those impacting the cardiovascular system and primary organ systems, leading to poor health outcomes, chronic disease, and earlier mortality (Dixon, 2010; Nejat, Polotsky, & Pal, 2010). The positive association between higher BMI, abdominal obesity and increased arterial stiffness in our sample of healthy adults is alarming because of the long term consequences seen in older adulthood especially concerning cognitive

functioning (Badji, Sabra, Bherer, Cohen-Adad, Girouard, & Gauthier, 2019; Dye, Boyle, Champ, & Lawton, 2017).

Our results add support to the idea that cardiovascular health is important to cognition, especially executive functions (Davenport, Hogan, Eskes, Longman, & Poulin, 2012; Barnes & Corkery, 2018; Hwang & Castelli, 2015). Moreover, our findings add further that cognitive functioning is related to arterial stiffness (Hajjar, Goldstein, Martin, & Quyyumi, 2016; Singer, Trollor, Baune, Sachdev, & Smith, 2014; Waldstein, Rice, Thayer, Najjar, Scuteri, & Zonderman, 2008). Our study adds to the literature when it comes to considering the specific inhibitory control abilities. It highlights the need to investigate separately the abilities that many researchers combine into one index of inhibitory control.

When investigating the role of cognition specifically with health behaviors, there is a need to investigate separately the types of inhibition based on their processes. This separation between response restraint and response cancellation can enhance the understanding and can indicate if they may have different implications when it comes to health behaviors. Evidence from Dohle, Diel, and Hofmann's (2018) systematic review does support that stopping (i.e. response cancellation ability) may be important to weight gain as unhealthy eating behaviors are strong prepotent actions which ruin dietary intentions. However, adiposity and health are not only influenced by eating behaviors. Nevertheless, their review does show the need for more primary research demonstrating how these specific inhibitory control processes specifically contribute to behaviors and health.

Considering the findings concerning the indices of adiposity, our results indicate that research needs to pay special attention to waist-to-hip ratios. Our study adds to the literature by showing that waist-to-hip ratio was not only associated with PFC hemoglobin levels during

response restraint but also performance during the response cancellation task. Yet, we do need to consider the general indices of obesity, as body mass index and body fat percentage were found to be related to PFC hemoglobin levels during the Stop Signal task. The strength of the findings is highlighted by the results surrounding arterial stiffness. Even in our sample of younger adults, arterial stiffness is related to response cancellation ability and mean level of PFC HbO<sub>2</sub> during the response restraint task. This strengthens the argument that cardiovascular health is crucial to cognitive performance but further extends it into a group of healthy younger adults. Taking all into account, the results demonstrate the importance of maintaining a healthy weight and health behaviors that support cardiovascular health (Kennedy et al., 2018; Bancks et al., 2019).

Overall, the current study is limited in its conclusions due to sample and methodological principals. Even though rigorous recruitment procedures were taken to get a wide variable sample, however, participants were younger and more educated. Likewise, the current study only used one index of each inhibition ability. A more robust manner to index these abilities would be to use multiple tasks to index response restraint and response cancellation, this allows for a more valid and reliable measure of the actual ability. Furthermore, since the design was correlational, causal associations cannot be made between health factors and cognitive performance. More importantly, neuroimaging data from fNIRS was averaged over trials, tasks, and areas. Variation in the trial data is lost and approaches based on cross random effects should be explored in future studies to model trial-level variability to better account for trial by trial changes in frontal hemodynamics (Hoffman & Rovine, 2007).

Collectively, findings from the current study help support the current idea that cognitive functioning is closely related to health, however, it also demonstrates the need for future

investigation with rigorous experimental design. Future studies will need to better dissect cognitive processes using robust cognitive task designs and neuroimaging paradigms that can better determine task-related PFC responses. Likewise, added measures of vascular health, inflammation, and body composition would add valuable information in explaining the mechanisms driving the relationship between health and cognitive functioning.

## REFERENCES

- Appelhans, B. M. (2009). Neurobehavioral inhibition of reward-driven feeding: implications for dieting and obesity. *Obesity*, 17(4), 640-647.
- Appointlet [Online software]. (2019). Retrieved from <https://www.appointlet.com>
- Aron, A. R., Fletcher, P. C., Bullmore, E. T., Sahakian, B. J., & Robbins, T. W. (2003). Stop-signal inhibition disrupted by damage to right inferior frontal gyrus in humans. *Nature Neuroscience*, 6(2), 115–116.
- Arvanitakis, Z., Capuano, A. W., Bennett, D. A., & Barnes, L. L. (2017). Body mass index and decline in cognitive function in older black and white persons. *Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences*, glx152.
- AtCor Medical Pty Ltd (2000). SphygmoCor - EM3: User Manual. Sydney, Australia. AtCord Medical Pty Ltd.
- Ayaz, H. (2005). “Analytical software and stimulus-presentation platform to utilize, visualize and analyze near-infrared spectroscopy measures”. MS Thesis, Drexel University, Philadelphia, PA.
- Ayaz, H. (2010). “Functional Near Infrared Spectroscopy based Brain Computer Interface”. Ph.D. Thesis, Drexel University, Philadelphia, PA.
- Ayaz, H., Izzetoglu, M., Shewokis, P. A., & Onaral, B. (2010, August). Sliding-window motion artifact rejection for functional near-infrared spectroscopy. In *Engineering in Medicine and Biology Society (EMBC), 2010 Annual International Conference of the IEEE* (pp. 6567-6570).

- Badji, A., Sabra, D., Bherer, L., Cohen-Adad, J., Girouard, H., & Gauthier, C. J. (2019). Arterial stiffness and brain integrity: A review of MRI findings. *Ageing Research Reviews*, 53, 100907.
- Bancks, M., Alonso, A., Allen, N., Yaffe, K., & Carnethon, M. (2019). Temporal trends in cognitive function of older US adults associated with population changes in demographic and cardiovascular profiles. *J Epidemiol Community Health*, 73(7), 612-618.
- Barkin, S. L. (2013). The relationship between executive function and obesity in children and adolescents: a systematic literature review. *Journal of obesity*, 2013.
- Batterink, L., Yokum, S., & Stice, E. (2010). Body mass correlates inversely with inhibitory control in response to food among adolescent girls: An fMRI study. *NeuroImage*, 52(4), 1696–1703.
- Baumeister, R. F. (2014). Self-regulation, ego depletion, and inhibition. *Neuropsychologia*, 65, 313-319.
- Boecker, M., Buecheler, M., Schroeter, M., & Gauggel, S. (2007). Prefrontal brain activation during stop-signal response inhibition: An event-related functional near-infrared spectroscopy study. *Behavioral Brain Research*, 176(2), 259–266.
- Bongers, P., van de Giessen, E., Roefs, A., Nederkoorn, C., Booij, J., van den Brink, W., & Jansen, A. (2015). Being impulsive and obese increases susceptibility to speeded detection of high-calorie foods. *Health Psychology*, 34(6), 677–685.
- Van Bortel, L. M., Laurent, S., Boutouyrie, P., Chowienczyk, P., Cruickshank, J. K., De Backer, T., Weber, T. (2012). Expert consensus document on the measurement of aortic stiffness in daily practice using carotid-femoral pulse wave velocity. *Journal of Hypertension*, 30(3), 445–448.

- Brook, R. D. (2006). Obesity, Weight Loss, and Vascular Function. *Endocrine*, 29(1), 21–26.
- Casey, B. J., Castellanos, F. X., Giedd, J. N., Marsh, W. L., Hamburger, S. D., Schubert, A. B., ... & Rapoport, J. L. (1997). Implication of right frontostriatal circuitry in response inhibition and attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, 36(3), 374-383.
- Caterini, J. E., Banks, L., Wells, G. D., Cifra, B., Slorach, C., McCrindle, B. W., & Seed, M. (2017). Magnetic resonance imaging reveals elevated aortic pulse wave velocity in obese and overweight adolescents. *Clinical obesity*, 7(6), 360-367.
- Chevrier, A. D., Noseworthy, M. D., & Schachar, R. (2007). Dissociation of response inhibition and performance monitoring in the stop signal task using event-related fMRI. *Human Brain Mapping*, 28(12), 1347–1358.
- Chung, S. C., Iwaki, S., Tack, G. R., Yi, J. H., You, J. H., & Kwon, J. H. (2006). Effect of 30% oxygen administration on verbal cognitive performance, blood oxygen saturation and heart rate. *Applied psychophysiology and biofeedback*, 31(4), 281-293.
- Clark, M. (2019, January 18). Introduction and Methods (Phase 1). Retrieved from [osf.io/2nd64](https://osf.io/2nd64)
- Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). Applied multiple regression/correlation analysis for the behavioral sciences (3rd ed.). Mahwah, NJ: Lawrence Erlbaum
- Cui, X., Bray, S., & Reiss, A. L. (2010). Functional near infrared spectroscopy (NIRS) signal improvement based on negative correlation between oxygenated and deoxygenated hemoglobin dynamics. *NeuroImage*, 49(4), 3039–3046
- Davenport, M. H., Hogan, D. B., Eskes, G. A., Longman, R. S., & Poulin, M. J. (2012). Cerebrovascular reserve. *Exercise and Sport Sciences Reviews*, 1.

- Deng, Z., Huang, Q., Huang, J., Zhang, W., Qi, C., & Xu, X. (2017). Association between central obesity and executive function as assessed by stroop task performance: A functional near-infrared spectroscopy study. *Journal of Innovative Optical Health Sciences*, 1750010.
- De Ridder, D. T. D., Lensvelt-Mulders, G., Finkenauer, C., Stok, F. M., & Baumeister, R. F. (2011). Taking Stock of Self-Control. *Personality and Social Psychology Review*, 16(1), 76–99.
- Dias, E. C., Foxe, J. J., & Javitt, D. C. (2003). Changing plans: a high-density electrical mapping study of cortical control. *Cerebral Cortex*, 13(7), 701-715.
- Dixon, J. B. (2010). The effect of obesity on health outcomes. *Molecular and cellular endocrinology*, 316(2), 104-108.
- Drigny, J., Gremeaux, V., Dupuy, O., Gayda, M., Bherer, L., Juneau, M., & Nigam, A. (2014). Effect of interval training on cognitive functioning and cerebral oxygenation in obese patients: a pilot study. *Journal of rehabilitation medicine*, 46(10), 1050-1054.
- Dupuy, O., Gauthier, C. J., Fraser, S. A., Desjardins-Crèpeau, L., Desjardins, M., Mekary, S., & Bherer, L. (2015). Higher levels of cardiovascular fitness are associated with better executive function and prefrontal oxygenation in younger and older women. *Frontiers in human neuroscience*, 9.
- Dye, L., Boyle, N. B., Champ, C., & Lawton, C. (2017). The relationship between obesity and cognitive health and decline. *Proceedings of the nutrition society*, 76(4), 443-454.
- Eagle, D. M., Bari, A., & Robbins, T. W. (2008). The neuropsychopharmacology of action inhibition: cross-species translation of the stop-signal and go/no-go tasks. *Psychopharmacology*, 199(3), 439–456.



- Elias, M. F., Robbins, M. A., Budge, M. M., Abhayaratna, W. P., Dore, G. A., & Elias, P. K. (2009). Arterial pulse wave velocity and cognition with advancing age. *Hypertension*, 53(4), 668-673.
- Elias, M. (2011). Norms and reference values for pulse wave velocity: one size does not fit all. *The Journal of Bioscience and Medicine*, 1(1), 1–10
- Enticott, P. G., Ogloff, J. R., & Bradshaw, J. L. (2006). Associations between laboratory measures of executive inhibitory control and self-reported impulsivity. *Personality and Individual Differences*, 41(2), 285-294.
- Erika-Florence, M., Leech, R., & Hampshire, A. (2014). A functional network perspective on response inhibition and attentional control. *Nature communications*, 5, 4073.
- Esposito, K., Marfella, R., Ciotola, M., Di Palo, C., Giugliano, F., Giugliano, G., & Giugliano, D. (2004). Effect of a Mediterranean-style diet on endothelial dysfunction and markers of vascular inflammation in the metabolic syndrome: a randomized trial. *Jama*, 292(12), 1440-1446.
- Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G\*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, 41, 1149-1160.
- Fernie, G., Peeters, M., Gullo, M. J., Christiansen, P., Cole, J. C., Sumnall, H., & Field, M. (2013). Multiple behavioural impulsivity tasks predict prospective alcohol involvement in adolescents. *Addiction*, 108(11), 1916–1923.
- Fernberg, U., Fernström, M., & Hurtig-Wennlöf, A. (2017). Arterial stiffness is associated to cardiorespiratory fitness and body mass index in young Swedish adults: The Lifestyle,

- Biomarkers, and Atherosclerosis study. *European Journal of Preventive Cardiology*, 2047487317720796.
- Ferrari, M., & Quaresima, V. (2012). A brief review on the history of human functional near-infrared spectroscopy (fNIRS) development and fields of application. *Neuroimage*, 63(2), 921-935.
- Fillmore, M. T., Rush, C. R., & Hays, L. (2006). Acute effects of cocaine in two models of inhibitory control: implications of non-linear dose effects. *Addiction*, 101(9), 1323–1332.
- Flegal, K. M., Carroll, M. D., Kit, B. K., & Ogden, C. L. (2012). Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *Jama*, 307(5), 491-497.
- Flegal, K. M., Kit, B. K., Orpana, H., & Graubard, B. I. (2013). Association of all-cause mortality with overweight and obesity using standard body mass index categories: a systematic review and meta-analysis. *Jama*, 309(1), 71-82.
- Freeman, L. R., Haley-Zitlin, V., Rosenberger, D. S., & Granholm, A.-C. (2013). Damaging effects of a high-fat diet to the brain and cognition: A review of proposed mechanisms. *Nutritional Neuroscience*, 17(6), 241–251.
- Gallagher, D., Heymsfield, S. B., Heo, M., Jebb, S. A., Murgatroyd, P. R., & Sakamoto, Y. (2000). Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. *The American journal of clinical nutrition*, 72(3), 694-701.
- Garavan, H. (2002). Dissociable Executive Functions in the Dynamic Control of Behavior: Inhibition, Error Detection, and Correction. *NeuroImage*, 17(4), 1820–1829.
- Gąsecki, D., Kwarciany, M., Nyka, W., & Narkiewicz, K. (2013). Hypertension, Brain Damage and Cognitive Decline. *Current Hypertension Reports*, 15(6), 547–558.

- Gerdan, G., & Kurt, M. (2020). Response inhibition according to the stimulus and food type in exogenous obesity. *Appetite*, 150, 104651.
- Global Database on Body Mass Index. (2007, December 01). Retrieved November 30, 2017, from <http://apps.who.int/bmi/index.jsp>
- Goldschmidt, A. B., O'Brien, S., Lavender, J. M., Pearson, C. M., Le Grange, D., & Hunter, S. J. (2018). Executive functioning in a racially diverse sample of children who are overweight and at risk for eating disorders. *Appetite*, 124, 43–49.
- Greenwood, C. E., & Winocur, G. (2005). High-fat diets, insulin resistance and declining cognitive function. *Neurobiology of aging*, 26(1), 42-45.
- Gunstad, J., Lhotsky, A., Wendell, C. R., Ferrucci, L., & Zonderman, A. B. (2010). Longitudinal Examination of Obesity and Cognitive Function: Results from the Baltimore Longitudinal Study of Aging. *Neuroepidemiology*, 34(4), 222–229.
- Gustafson, D. R., Steen, B., & Skoog, I. (2004). Body mass index and white matter lesions in elderly women. An 18-year longitudinal study. *International Psychogeriatrics*, 16(3), 327-336.
- Gustafson, D., Lissner, L., Bengtsson, C., Björkelund, C., & Skoog, I. (2004). A 24-year follow-up of body mass index and cerebral atrophy. *Neurology*, 63(10), 1876-1881.
- Gustafson, D., Rothenberg, E., Blennow, K., Steen, B., & Skoog, I. (2003). An 18-year follow-up of overweight and risk of Alzheimer disease. *Archives of internal medicine*, 163(13), 1524-1528.
- Guxens, M., Mendez, M. A., Julvez, J., Plana, E., Forns, J., Basagana, X., Sunyer, J. (2009). Cognitive Function and Overweight in Preschool Children. *American Journal of Epidemiology*, 170(4), 438–446.

- Hajjar, I., Goldstein, F. C., Martin, G. S., & Quyyumi, A. A. (2016). Roles of Arterial Stiffness and Blood Pressure in Hypertension-Associated Cognitive Decline in Healthy Adults. *Hypertension*, 67(1), 171–175.
- Hales, C. M., Fryar, C. D., Carroll, M. D., Freedman, D. S., & Ogden, C. L. (2018). Trends in obesity and severe obesity prevalence in US youth and adults by sex and age, 2007-2008 to 2015-2016. *Jama*, 319(16), 1723-1725.
- Hargrave, S. L., Jones, S., & Davidson, T. L. (2016). The outward spiral: a vicious cycle model of obesity and cognitive dysfunction. *Current Opinion in Behavioral Sciences*, 9, 40–46.
- Heitz, R. P., Redick, T. S., Hambrick, D. Z., Kane, M. J., Conway, A. R. A., & Engle, R. W. (2006). Working memory, executive function, and general fluid intelligence are not the same. *Behavioral and Brain Sciences*, 29(02).
- Hendrick, O. M., Luo, X., Zhang, S., & Li, C. S. R. (2012). Saliency processing and obesity: a preliminary imaging study of the stop signal task. *Obesity*, 20(9), 1796-1802.
- Henskens, L. H., van Oostenbrugge, R. J., Kroon, A. A., Hofman, P. A., Lodder, J., & de Leeuw, P. W. (2009). Detection of silent cerebrovascular disease refines risk stratification of hypertensive patients. *Journal of Hypertension*, 27(4), 846–853.
- Herouvi, D., Karanasios, E., Karayianni, C., & Karavanaki, K. (2013). Cardiovascular disease in childhood: the role of obesity. *European journal of pediatrics*, 172(6), 721-732.
- Herrmann, M. J., Plichta, M. M., Ehlis, A. C., & Fallgatter, A. J. (2005). Optical topography during a Go–NoGo task assessed with multi-channel near-infrared spectroscopy. *Behavioural brain research*, 160(1), 135-140.
- Hoffman, L., & Rovine, M. J. (2007). Multilevel models for the experimental psychologist: Foundations and illustrative examples. *Behavior Research Methods*, 39(1), 101-117.

- Howarth, C., Gleeson, P., & Attwell, D. (2012). Updated Energy Budgets for Neural Computation in the Neocortex and Cerebellum. *Journal of Cerebral Blood Flow & Metabolism*, 32(7), 1222–1232.
- Huppert, T. J., Hoge, R. D., Diamond, S. G., Franceschini, M. A., & Boas, D. A. (2006). A temporal comparison of BOLD, ASL, and NIRS hemodynamic responses to motor stimuli in adult humans. *Neuroimage*, 29(2), 368-382.
- Hudson, L. D., Rapala, A., Khan, T., Williams, B., & Viner, R. M. (2015). Evidence for contemporary arterial stiffening in obese children and adolescents using pulse wave velocity: a systematic review and meta-analysis. *Atherosclerosis*, 241(2), 376-386.
- Hurr, C., Patik, J. C., Kim, K., & Brothers, R. M. (2017). Blunted cerebral vascular responsiveness to hypercapnia in obese individuals. *Experimental Physiology*, 102(10), 1300-1308.
- Huynh, Q., Blizzard, L., Sharman, J., Magnussen, C., Schmidt, M., Dwyer, T., & Venn, A. (2013). Relative contributions of adiposity in childhood and adulthood to vascular health of young adults. *Atherosclerosis*, 228(1), 259–264.
- Hsu, J. S., Wang, P. W., Ko, C. H., Hsieh, T. J., Chen, C. Y., & Yen, J. Y. (2017). Altered brain correlates of response inhibition and error processing in females with obesity and sweet food addiction: A functional magnetic imaging study. *Obesity research & clinical practice*, 11(6), 677-686.
- Hwang, J., & Castelli, D. M. (2015). Association of cardiorespiratory fitness and vascular risk on cognitive function in young adults. *Medical Research Archives*, (3).

- Iantorno, M., Campia, U., Di Daniele, N., Nistico, S., Forleo, G. B., Cardillo, C., & Tesouro, M. (2014). Obesity, inflammation and endothelial dysfunction. *J Biol Regul Homeost Agents*, 28(2), 169-176.
- Inoue, Y., Qin, B., Poti, J., Sokol, R., & Gordon-Larsen, P. (2018). Epidemiology of obesity in adults: latest trends. *Current obesity reports*, 7(4), 276-288.
- Inquisit 5 [Computer software]. (2016). Retrieved from <https://www.millisecond.com>.
- Jagielski, A. C., Brown, A., Hosseini-Araghi, M., Thomas, G. N., & Taheri, S. (2014). The association between adiposity, mental well-being, and quality of life in extreme obesity. *PloS one*, 9(3), e92859.
- Jeronicic, A., Gunjaca, G., Mrsic, D. B., Mudnic, I., Brizic, I., Polasek, O., & Boban, M. (2016). Normative equations for central augmentation index: assessment of inter-population applicability and how it could be improved. *Scientific Reports*, 6(1).
- Karunathilaka, D. R. N., Hewage, D. C., Wimalasekera, S. W., & Amarasekara, A. A. T. D. (2016). Gender, Body Mass Index and Waist to Hip Ratio and Inhibitory Control in a Sample of Young Adults in Colombo District, Sri Lanka.
- Kennedy, G., Meyer, D., Hardman, R. J., Macpherson, H., Scholey, A. B., & Pipingas, A. (2018). Physical fitness and aortic stiffness explain the reduced cognitive performance associated with increasing age in older people. *Journal of Alzheimer's Disease*, 63(4), 1307-1316.
- Kennedy, K. M., & Raz, N. (2009). Pattern of normal age-related regional differences in white matter microstructure is modified by vascular risk. *Brain research*, 1297, 41-56.

- Konishi, S., Nakajima, K., Uchida, I., Kikyo, H., Kameyama, M., & Miyashita, Y. (1999). Common inhibitory mechanism in human inferior prefrontal cortex revealed by event-related functional MRI. *Brain*, 122(5), 981-991.
- Kulendran, M., Vlaev, I., Sugden, C., King, D., Ashrafian, H., Gately, P., & Darzi, A. (2014). Neuropsychological assessment as a predictor of weight loss in obese adolescents. *International journal of obesity*, 38(4), 507.
- Kurth, F., Levitt, J. G., Phillips, O. R., Luders, E., Woods, R. P., Mazziotta, J. C., ... Narr, K. L. (2012). Relationships between gray matter, body mass index, and waist circumference in healthy adults. *Human Brain Mapping*, 34(7), 1737–1746.
- Lavagnino, L., Arnone, D., Cao, B., Soares, J. C., & Selvaraj, S. (2016). Inhibitory control in obesity and binge eating disorder: A systematic review and meta-analysis of neurocognitive and neuroimaging studies. *Neuroscience & Biobehavioral Reviews*, 68, 714–726.
- Lavie, C. J., McAuley, P. A., Church, T. S., Milani, R. V., & Blair, S. N. (2014). Obesity and Cardiovascular Diseases. *Journal of the American College of Cardiology*, 63(14), 1345–1354.
- Lehnert, T., Sonntag, D., Konnopka, A., Riedel-Heller, S., & König, H. H. (2013). Economic costs of overweight and obesity. *Best practice & research Clinical endocrinology & metabolism*, 27(2), 105-115.
- León-Carrion, J., Damas-López, J., Martín-Rodríguez, J. F., Domínguez-Roldán, J. M., Murillo-Cabezas, F., y Martin, J. M. B., & Domínguez-Morales, M. R. (2008). The hemodynamics of cognitive control: the level of concentration of oxygenated hemoglobin

- in the superior prefrontal cortex varies as a function of performance in a modified Stroop task. *Behavioural brain research*, 193(2), 248-256.
- Levitan, R. D., Rivera, J., Silveira, P. P., Steiner, M., Gaudreau, H., Hamilton, J., & Wazana, A. (2015). Gender differences in the association between stop-signal reaction times, body mass indices and/or spontaneous food intake in pre-school children: an early model of compromised inhibitory control and obesity. *International Journal of Obesity*, 39(4), 614.
- Li, Y., Grabell, A. S., Wakschlag, L. S., Huppert, T. J., & Perlman, S. B. (2017). The neural substrates of cognitive flexibility are related to individual differences in preschool irritability: a fNIRS investigation. *Developmental cognitive neuroscience*, 25, 138-144.
- Lima, V. V., Giachini, F. R., Matsumoto, T., Li, W., Bressan, A. F., Chawla, D., & Tostes, R. C. (2016). High-fat diet increases O-GlcNAc levels in cerebral arteries: a link to vascular dysfunction associated with hyperlipidemia/obesity? *Clinical Science*, 130(11), 871-880.
- Littman, R., & Takács, Á. (2017). Do all inhibitions act alike? A study of go/no-go and stop-signal paradigms. *PLOS ONE*, 12(10), e0186774.
- Logan, G. D., Cowan, W. B., & Davis, K. A. (1984). On the ability to inhibit simple and choice reaction time responses: a model and a method. *Journal of Experimental Psychology: Human Perception and Performance*, 10(2), 276.
- Logan, G. D. (1994). On the ability to inhibit thought and action: A users' guide to the stop signal paradigm. In D. Dagenbach & T. H. Carr (Eds.), *Inhibitory processes in attention, memory, and language* (p. 189–239). Academic Press.
- Logan, G. D., Schachar, R. J., & Tannock, R. (1997). Impulsivity and inhibitory control. *Psychological science*, 8(1), 60-64.



- Maayan, L., Hoogendoorn, C., Sweat, V., & Convit, A. (2011). Disinhibited eating in obese adolescents is associated with orbitofrontal volume reductions and executive dysfunction. *Obesity*, 19(7), 1382-1387.
- McKendrick, R., Feest, B., Harwood, A., & Falcone, B. (2019). Theories and Methods for Labeling Cognitive Workload: Classification and Transfer Learning. *Frontiers in Human Neuroscience*, 13.
- Miao, S., Han, J., Gu, Y., Wang, X., Song, W., Li, D., Li, X. (2017). Reduced Prefrontal Cortex Activation in Children with Attention-Deficit/Hyperactivity Disorder during Go/No-Go Task: A Functional Near-Infrared Spectroscopy Study. *Frontiers in Neuroscience*, 11.
- Mitchell, G. F., Parise, H., Benjamin, E. J., Larson, M. G., Keyes, M. J., Vita, J. A., ... Levy, D. (2004). Changes in Arterial Stiffness and Wave Reflection With Advancing Age in Healthy Men and Women. *Hypertension*, 43(6), 1239–1245.
- Mensah, G. A., Croft, J. B., & Giles, W. H. (2002). The heart, kidney, and brain as target organs in hypertension. *Cardiology Clinics*, 20(2), 225–247.
- Mekari, S., Dupuy, O., Martins, R., Evans, K., Kimmerly, D. S., Fraser, S., & Neyedli, H. F. (2019). The effects of cardiorespiratory fitness on executive function and prefrontal oxygenation in older adults. *GeroScience*, 41(5), 681-690.
- Mobbs, O., Iglesias, K., Golay, A., & Van der Linden, M. (2011). Cognitive deficits in obese persons with and without binge eating disorder. Investigation using a mental flexibility task. *Appetite*, 57(1), 263-271.
- Monden, Y., Dan, I., Nagashima, M., Dan, H., Uga, M., Ikeda, T., Yamagata, T. (2015). Individual classification of ADHD children by right prefrontal hemodynamic responses during a go/no-go task as assessed by fNIRS. *NeuroImage: Clinical*, 9, 1–12.

- Must, A., Spadano, J., Coakley, E. H., Field, A. E., Colditz, G., & Dietz, W. H. (1999). The disease burden associated with overweight and obesity. *Jama*, 282(16), 1523-1529.
- Gr NCD Risk Factor Collaboration. (2016). Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants. *The Lancet*, 387(10026), 1377-1396.
- Nederkoorn, C., Houben, K., Hofmann, W., Roefs, A., & Jansen, A. (2010). Control yourself or just eat what you like? Weight gain over a year is predicted by an interactive effect of response inhibition and implicit preference for snack foods. *Health Psychology*, 29(4), 389–393.
- Nederkoorn, C., Smulders, F. T., Havermans, R. C., Roefs, A., & Jansen, A. (2006). Impulsivity in obese women. *Appetite*, 47(2), 253-256.
- Nejat, E. J., Polotsky, A. J., & Pal, L. (2010). Predictors of chronic disease at midlife and beyond-the health risks of obesity. *Maturitas*, 65(2), 106-111.
- Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., & Abraham, J. P. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. *The lancet*, 384(9945), 766-781.
- Nguyen, J. C. D., Killcross, A. S., & Jenkins, T. A. (2014). Obesity and cognitive decline: role of inflammation and vascular changes. *Frontiers in Neuroscience*, 8.
- Ge, Q., Brichard, S., Yi, X., & Li, Q. (2014). microRNAs as a New Mechanism Regulating Adipose Tissue Inflammation in Obesity and as a Novel Therapeutic Strategy in the Metabolic Syndrome. *Journal of Immunology Research*, 2014, 1–10.

- Ohkuma, T., Ninomiya, T., Tomiyama, H., Kario, K., Hoshida, S., Kita, Y., & Nakamura, M. (2017). Brachial-Ankle Pulse Wave Velocity and the Risk Prediction of Cardiovascular Disease. *Hypertension*, hypertensionaha-117.
- O'Rourke, M. F., & Safar, M. E. (2005). Relationship Between Aortic Stiffening and Microvascular Disease in Brain and Kidney. *Hypertension*, 46(1), 200–204.
- Osika, W., & Montgomery, S. M. (2008). Physical control and coordination in childhood and adult obesity: longitudinal birth cohort study. *BMJ*, 337(aug12 3), a699–a699.
- Panagiotakos, D. B., Pitsavos, C., Yannakoulia, M., Chryschoou, C., & Stefanadis, C. (2005). The implication of obesity and central fat on markers of chronic inflammation: The ATTICA study. *Atherosclerosis*, 183(2), 308-315.
- Pauli-Pott, U., Albayrak, Ö., Hebebrand, J., & Pott, W. (2010). Association between inhibitory control capacity and body weight in overweight and obese children and adolescents: dependence on age and inhibitory control component. *Child Neuropsychology*, 16(6), 592-603.
- Pliszka, S. R., Liotti, M., & Woldorff, M. G. (2000). Inhibitory control in children with attention-deficit/hyperactivity disorder: event-related potentials identify the processing component and timing of an impaired right-frontal response-inhibition mechanism. *Biological psychiatry*, 48(3), 238-246.
- Poels, M. M., van Oijen, M., Mattace-Raso, F. U., Hofman, A., Koudstaal, P. J., Witteman, J. C., & Breteler, M. M. (2007). Arterial stiffness, cognitive decline, and risk of dementia: the Rotterdam study. *Stroke*, 38(3), 888-892.

- Prickett, C., Brennan, L., & Stolwyk, R. (2015). Examining the relationship between obesity and cognitive function: a systematic literature review. *Obesity research & clinical practice*, 9(2), 93-113.
- Prins, N. D., van Dijk, E. J., den Heijer, T., Vermeer, S. E., Jolles, J., Koudstaal, P. J., ... Breteler, M. M. B. (2005). Cerebral small-vessel disease and decline in information processing speed, executive function and memory. *Brain*, 128(9), 2034–2041.
- QuestionPro [Online software]. (2019). Retrieved from <https://www.questionpro.com/>.
- Randall, W. M., & Smith, J. L. (2011). Conflict and inhibition in the cued-Go/NoGo task. *Clinical Neurophysiology*, 122(12), 2400-2407.
- Recio-Rodriguez, J. I., Gomez-Marcos, M. A., Patino-Alonso, M. C., Agudo-Conde, C., Rodriguez-Sanchez, E., & Garcia-Ortiz, L. (2012). Abdominal obesity vs general obesity for identifying arterial stiffness, subclinical atherosclerosis and wave reflection in healthy, diabetics and hypertensive. *BMC cardiovascular disorders*, 12(1), 3.
- Rodríguez-Flores, M., García-García, E., Cano-Nigenda, C., & Cantú-Brito, C. (2014). Relationship of obesity and insulin resistance with the cerebrovascular reactivity: a case control study. *Cardiovascular Diabetology*, 13(1), 2.
- Sansal, F., Gokdag, Y. E., Sahin, D., Keskin, Y., Yilmaz, O., & Akin, A. (2014). Frontal brain activation during a Go/NoGo response inhibition task: An fNIRS study. 2014 22nd *Signal Processing and Communications Applications Conference (SIU)*.
- Schachar, R., Logan, G. D., Robaey, P., Chen, S., Ickowicz, A., & Barr, C. (2007). Restraint and Cancellation: Multiple Inhibition Deficits in Attention Deficit Hyperactivity Disorder. *Journal of Abnormal Child Psychology*, 35(2), 229–238.

- Schlaich, M. P., Grassi, G., Lambert, G. W., Straznicky, N., Esler, M. D., Dixon, J., Jordan, J. (2009). European Society of Hypertension Working Group on Obesity Obesity-induced hypertension and target organ damage: current knowledge and future directions. *Journal of Hypertension*, 27(2), 207–211.
- Schroeter, M. L., Zysset, S., Kupka, T., Kruggel, F., & Von Cramon, D. Y. (2002). Near-infrared spectroscopy can detect brain activity during a color–word matching Stroop task in an event-related design. *Human brain mapping*, 17(1), 61-71.
- Schroeter, M. L., Zysset, S., Kupka, T., Kruggel, F., & Von Cramon, D. Y. (2002). Near-infrared spectroscopy can detect brain activity during a color–word matching Stroop task in an event-related design. *Human brain mapping*, 17(1), 61-71.
- Schroeter, M. L., Zysset, S., Wahl, M., & von Cramon, D. Y. (2004). Prefrontal activation due to Stroop interference increases during development—an event-related fNIRS study. *Neuroimage*, 23(4), 1317-1325.
- Schroeter, M. L., Zysset, S., Kruggel, F., & von Cramon, D. Y. (2003). Age dependency of the hemodynamic response as measured by functional near-infrared spectroscopy. *NeuroImage*, 19(3), 555–564.
- Shackman, A. J., McMenamin, B. W., Maxwell, J. S., Greischar, L. L., & Davidson, R. J. (2009). Right dorsolateral prefrontal cortical activity and behavioral inhibition. *Psychological science*, 20(12), 1500-1506.
- Shelton, R. C., & Miller, A. H. (2010). Eating ourselves to death (and despair): the contribution of adiposity and inflammation to depression. *Progress in neurobiology*, 91(4), 275-299.

- Short, K. R., Blackett, P. R., Gardner, A. W., & Copeland, K. C. (2009). Vascular health in children and adolescents: effects of obesity and diabetes. *Vascular health and risk management*, 5, 973.
- Sierra, C., López-Soto, A., & Coca, A. (2011). Connecting Cerebral White Matter Lesions and Hypertensive Target Organ Damage. *Journal of Aging Research*, 2011, 1–7.
- Silvers, J. A., Insel, C., Powers, A., Franz, P., Weber, J., Mischel, W., & Ochsner, K. N. (2014). Curbing craving: behavioral and brain evidence that children regulate craving when instructed to do so but have higher baseline craving than adults. *Psychological science*, 25(10), 1932-1942.
- Singer, J., Trollor, J. N., Baune, B. T., Sachdev, P. S., & Smith, E. (2014). Arterial stiffness, the brain and cognition: A systematic review. *Ageing Research Reviews*, 15, 16–27.
- Singer, K., & Lumeng, C. N. (2017). The initiation of metabolic inflammation in childhood obesity. *Journal of Clinical Investigation*, 127(1), 65–73.
- Smith, E., Hay, P., Campbell, L., & Trollor, J. N. (2011). A review of the association between obesity and cognitive function across the lifespan: implications for novel approaches to prevention and treatment. *Obesity reviews*, 12(9), 740-755.
- Smith, J. L., Mattick, R. P., Jamadar, S. D., & Iredale, J. M. (2014). Deficits in behavioural inhibition in substance abuse and addiction: A meta-analysis. *Drug and Alcohol Dependence*, 145, 1–33.
- Smith, P. J., Blumenthal, J. A., Babyak, M. A., Craighead, L., Welsh-Bohmer, K. A., Browndyke, J. N., & Sherwood, A. (2010). Effects of the Dietary Approaches to Stop Hypertension Diet, Exercise, and Caloric Restriction on Neurocognition in Overweight Adults with High Blood Pressure. *Hypertension*, 55(6), 1331–1338.

- Strangman, G., Culver, J. P., Thompson, J. H., & Boas, D. A. (2002). A quantitative comparison of simultaneous BOLD fMRI and NIRS recordings during functional brain activation. *Neuroimage*, 17(2), 719-731.
- Strangman, G., Franceschini, M. A., & Boas, D. A. (2003). Factors affecting the accuracy of near-infrared spectroscopy concentration calculations for focal changes in oxygenation parameters. *Neuroimage*, 18(4), 865-879.
- Stingl, K. T., Kullmann, S., Ketterer, C., Heni, M., Häring, H.-U., Fritsche, A., & Preissl, H. (2012). Neuronal correlates of reduced memory performance in overweight subjects. *Neuroimage*, 60(1), 362–369.
- Sutton-Tyrrell, K., Najjar, S. S., Boudreau, R. M., Venkitachalam, L., Kupelian, V., Simonsick, E. M., & Pahor, M. (2005). Elevated aortic pulse wave velocity, a marker of arterial stiffness, predicts cardiovascular events in well-functioning older adults. *Circulation*, 111(25), 3384-3390.
- Tan, J., Pei, Y., Hua, Q., Xing, X., & Wen, J. (2014). Aortic Pulse Wave Velocity is Associated with Measures of Subclinical Target Organ Damage in Patients with Mild Hypertension. *Cell Biochemistry and Biophysics*, 70(1), 167–171.
- Tran, T. M., & Giang, N. M. (2014). Changes in blood pressure classification, blood pressure goals and pharmacological treatment of essential hypertension in medical guidelines from 2003 to 2013. *IJC Metabolic & Endocrine*, 2, 1-10.
- Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N., & Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Applied Physiology, Nutrition, and Metabolism*, 35(6), 725–740.

- Van Gaal, L. F., Mertens, I. L., & De Block, C. E. (2006). Mechanisms linking obesity with cardiovascular disease. *Nature*, 444(7121), 875.
- Van Wouwe, N. C., Claassen, D. O., Neimat, J. S., Kanoff, K. E., & Wylie, S. A. (2017). Dopamine Selectively Modulates the Outcome of Learning Unnatural Action–Valence Associations. *Journal of Cognitive Neuroscience*, 29(5), 816–826.
- Vaughan, L., & Giovanello, K. (2010). Executive function in daily life: Age-related influences of executive processes on instrumental activities of daily living. *Psychology and Aging*, 25(2), 343–355.
- Verbruggen, F., Chambers, C. D., & Logan, G. D. (2013). Fictitious inhibitory differences: how skewness and slowing distort the estimation of stopping latencies. *Psychological science*, 24(3), 352-362.
- Volkow, N. D., Wang, G.-J., Tomasi, D., & Baler, R. D. (2012). Obesity and addiction: neurobiological overlaps. *Obesity Reviews*, 14(1), 2–18.
- Waldstein, S. R., Rice, S. C., Thayer, J. F., Najjar, S. S., Scuteri, A., & Zonderman, A. B. (2008). Pulse Pressure and Pulse Wave Velocity Are Related to Cognitive Decline in the Baltimore Longitudinal Study of Aging. *Hypertension*, 51(1), 99–104.
- Watson, N. L., Sutton-Tyrrell, K., Rosano, C., Boudreau, R. M., Hardy, S. E., Simonsick, E. M., Newman, A. B. (2011). Arterial Stiffness and Cognitive Decline in Well-Functioning Older Adults. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 66A(12), 1336–1342.
- Wardle, J. (1988). Cognitive control of eating. *Journal of psychosomatic research*, 32(6), 607-612.



- Whiteside, S. P., & Lynam, D. R. (2001). The five-factor model and impulsivity: Using a structural model of personality to understand impulsivity. *Personality and individual differences*, 30(4), 669-689.
- Wijekumar, S., Magnotta, V. A., Buss, A. T., Ambrose, J. P., Wifall, T. A., Hazeltine, E., & Spencer, J. P. (2015). Response control networks are selectively modulated by attention to rare events and memory load regardless of the need for inhibition. *NeuroImage*, 120, 331–344.
- Wildman, R. P., Mackey, R. H., Bostom, A., Thompson, T., & Sutton-Tyrrell, K. (2003). Measures of obesity are associated with vascular stiffness in young and older adults. *Hypertension*, 42(4), 468-473.
- Wilkinson, I. B., Cockcroft, J. R., & Webb, D. J. (1998). Pulse wave analysis and arterial stiffness. *Journal of cardiovascular pharmacology*, 32, S33-7.
- Wohlfahrt, P., Somers, V. K., Cifkova, R., Filipovsky, J., Seidlerova, J., Krajcoviechova, A., & Lopez-Jimenez, F. (2014). Relationship between measures of central and general adiposity with aortic stiffness in the general population. *Atherosclerosis*, 235(2), 625-631.
- Woo, K. S., Chook, P., Yu, C. W., Sung, R. Y., Qiao, M., Leung, S. S., & Celermajer, D. S. (2004). Effects of diet and exercise on obesity-related vascular dysfunction in children. *Circulation*, 109(16), 1981-1986.
- World Health Organization: Adult BMI. (2017, June 29). Retrieved August 29, 2019, from [https://www.cdc.gov/healthyweight/assessing/bmi/adult\\_bmi/index.html](https://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html).
- World Health Organization. (2013). Global action plan for the prevention and control of noncommunicable diseases 2013-2020.

- World Health Organization. (2011). Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, 8-11 December 2008.
- Xu, X., Ying, Z., Cai, M., Xu, Z., Li, Y., Jiang, S. Y., & Rajagopalan, S. (2011). Exercise ameliorates high-fat diet-induced metabolic and vascular dysfunction and increases adipocyte progenitor cell population in brown adipose tissue. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, 300(5), R1115-R1125.
- Yang, L., & Colditz, G. A. (2015). Prevalence of overweight and obesity in the United States, 2007-2012. *JAMA internal medicine*, 175(8), 1412-1413.
- Yudkin, J. S. (2003). Adipose tissue, insulin action and vascular disease: inflammatory signals. *International Journal of Obesity*, 27(S3), S25.
- Zhang, R., Geng, X., & Lee, T. M. C. (2017). Large-scale functional neural network correlates of response inhibition: an fMRI meta-analysis. *Brain Structure and Function*, 222(9), 3973–3990.
- Zieman, S. J., Melenovsky, V., & Kass, D. A. (2005). Mechanisms, pathophysiology, and therapy of arterial stiffness. *Arteriosclerosis, thrombosis, and vascular biology*, 25(5), 932-943.

## APPENDIX A

### Recruitment Procedures

Performance for Your Post		
<b>37,155</b> People Reached		
<b>587</b> Reactions, Comments & Shares		
65 Like	4 On Post	61 On Shares
2 Love	1 On Post	1 On Shares
1 Haha	0 On Post	1 On Shares
1 Wow	0 On Post	1 On Shares
1 Sad	0 On Post	1 On Shares
26 Comments	4 On Post	22 On Shares
491 Shares	462 On Post	29 On Shares
<b>1,378</b> Post Clicks		
219 Photo Views	60 Link Clicks	1,099 Other Clicks
NEGATIVE FEEDBACK		
0 Hide Post	0 Hide All Posts	
0 Report as Spam	0 Unlike Page	

Recruitment started on April 9th, 2019 and ended March, 26 2020. On Facebook, two posts invited people to participate (Appendix A). Post A was shared on approximately 37 local Facebook groups one to two times per month. The number of group members ranged from 403 to 107,671.

Facebook post statistics indicate that 37, 155 people viewed the post and had 1,965 interactions which include Likes, Comments, or Shares. The post was clicked 1,378 which include; 60 clicks on the “learn more button”, 219 clicks on the post photo, and 1,099 clicks on either the links contained within the text of the post or the title of the post.

Since Facebook limits the text allowed on paid ad posts, paid ads used a different post photo (Appendix A, Post B). Post B reached 592 people and had 143 engagements (clicks, comments, shares) over a one-month period and cost \$18.38 USD. Post B engagements were primary made on the Facebook news feed on the Facebook mobile App (67.3%) by females (71.9%) age 35 to 44.

### Social Media Post/Craigslist Ad Text

Hey El Paso! Are you 18 to 50 years old? Are you free of any major medical conditions & skin allergies? If you answered yes to these, you should be eligible to participate in a short study. We will measure your body fat percentage and vascular health. Then you will complete a few computerized tasks while having your brain monitored with a device which looks like a headband. The study lasts for about an hour and thirty minutes. Parking will be provided on campus. Afterwards you will be provided with data on our findings and a \$15 Walmart gift card. We are looking for people of all fitness levels- low to high and all body types! Use the Link below to see if you qualify and to sign up for the study.

<https://utepstudyeligibility.questionpro.com> Give Us a Call if interested (915) 209 -1441 Many thanks!

### Print Recruitment Ads

Two different types of flyers were placed in public places including the University of Texas El Paso, two public libraries, and two public posting boards in commercial centers. The flyers were printed on 11x17 paper and 9.5x11 paper in both black and white and in color. Color flyers were placed in the libraries and commercial centers. Permission was received from the facilities to place the signage.

### Changes in Recruitment Procedure

Checks were performed on participant demographics to ensure variation of participant age. In the August, the majority (65%) were under the age of 30. Changes to recruitment materials (changing the age range from 18-50 to 30-50) were submitted and approved by the IRB. This change allowed for recruitment to focus on older participants since a larger number of young participants were willing to participate.

### Appendix A (continued)



## APPENDIX B

### Eligibility Questionnaire

**Page 1** Thanks for your interest in our research study. This six-question survey will determine if you are eligible to participate. Your participation in this survey is completely voluntary. However, if you feel uncomfortable answering any questions, you can withdraw from the survey at any point. Your responses will be strictly confidential, and no identifying data is collected it is only to determine eligibility for the UTEP health research study. Thank you very much for your time and support. Please start with the survey now by clicking on the NEXT button below.

**Page 2** What is your age?

**Page 3** Do you have any skin allergies, such as to latex? Yes No

**Page 4** Do you use any type of tobacco products (cigarettes, e-cigarettes, chewing, etc.)? Yes No

**Page 5** Have you been diagnosed with and/or take medicines for any of the conditions below?

Yes No

High Blood Pressure (Hypertension)

High Cholesterol (Hyperlipidemia)

Coronary Atherosclerosis

Coronary Heart Disease

Diabetes

Metabolic Syndrome

Hypothyroidism

Hyperthyroidism

Chronic Fatigue Syndrome

Recently Pregnant or Nursing

Alcohol or Drug Dependence

**Page 6** Have you ever suffered a traumatic brain injury or major head injury? Yes No

**Page 7** Are you able to travel to UTEP to take part in the research study? Yes No

If the participant stated they were between the ages of 18-50 and answered No to questions 2-6, and Yes to question 7, they were deemed eligible and redirected to appointment system via Appointlet.com where they could select their study time. If participants were not in the age range or answered yes to any of questions 2-6, or no to question 7 they were deemed ineligible and redirected to a page thanking them for their interest and providing contact information for further information.

In total, the eligibility questionnaire was viewed 1,814 times and started by 441 potential participants with 195 people stopping mid questionnaire. Of the people who stopped, 13% did so on the 1<sup>st</sup> page, 3% on the 2<sup>nd</sup> page, 1% on the 3<sup>rd</sup> page, 2% on the 4<sup>th</sup> page, 14% on the 5<sup>th</sup> page, 6% were on the 6<sup>th</sup> page, and 59% on the 7<sup>th</sup> question. Overall, 103 did not meet recruitment criteria, and 143 successfully completed the screener and were redirected to the online appointment system hosted on Appointlet.com.

### Appointet.com Appointment Scheduling

As indicated by the Appointlet.com scheduling system there was a total of 133 appointments scheduled. Of these, 70 participants attended their appointment. Twenty participants either cancelled or had their appointment cancelled. Seven participants rescheduled their appointments and 22 participants did not show up for the scheduled appointment. When participants did not show up to their appointment contact was attempted via SMS and phone call.

## APPENDIX C

### Demographics Questionnaire

1. What is your gender?
2. What year were you born?
3. What month were you born?
4. What is your race/ethnicity? (Select all that apply)
 

1. White/Caucasian	4. Asian	7. Other
2. African American	5. Native American	
3. Hispanic	6. Pacific Islander	
5. What is your primary language (the language that you speak most often with friends/family)?
 

1. English	2. Spanish	3. Other
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6. How would you rate your language proficiency?
 

	Terrible	Poor	Average (Proficient)	Good	Excellent	N/A
English	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Spanish	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other (If indicated above)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. What is your occupation? (e.g. Unemployed, Student, military, self-employed, medicine etc.)
8. What is the highest degree of education you have received?
 

1. Professional or Honors (Ph.D, MD, JD, etc.)	2. Graduate (MA, MBA, MS, LLM, etc.)
3. Undergraduate (AA, BA, BS, Specialty Certification)	4. High school certificate (GED, Diploma)
5. Completed Middle school	
9. What is your household's monthly income before taxes?
 

1. Less than \$850	2. \$850 to \$2,000	3. \$2,000 to \$3,999	4. \$4,000 to \$6,999
5. \$7,000 to \$11,999		6. Above \$12,000	
10. Do you currently use any tobacco products? (e.g. Cigarettes, cigars, e-cigarettes, chew, etc.)
11. If so, when was the last time you smoked (or when you quit)? (\*If never smoked please click Not Applicable in the box)
 

1. Less than 30 days	2. Within 30 days	3. 2 to 6 months	4. 6 to 12 months
5. Greater than 12 months		6. Not Applicable	
12. Do you currently consume alcohol?
13. If you do consume alcohol, how many days a week do you consume alcohol?
14. On a weekly average, how many times did you perform...
 

	0 times	1 time	2-3 times	4-5 times	6-7 times
Light intensive activities (e.g. walking, standing for excess periods, etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Moderate intensive activities (e.g. Brisk walking, heaving cleaning, light cycling, etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Vigorous intensive activities (Jogging, running, weightlifting, heavy lifting, etc)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15. On average, how many times a day within the past week did you exercise for at least 30 minutes?
 

1. Less than 1 time	2. 1-2 times	3. 3-4 times	4. 4 or more times	5. Everyday
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**16. On an average night, how many consecutive, undisturbed hours of sleep do you think you get?**

1. 2 Hours or less    2. 3-4 Hours    3. 5-6 Hours    4. 7-8 Hours    5. 9-10 Hours    6. 10 Hours or >

**17. Generally, how do you rate the following aspects of your sleep?**

	1 Poor	2	3	4	5 Excellent
<b>Quality</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Length</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**18. In general, after a typical night's rest, how do you feel?**

	Very unsatisfied, grumpy and fatigued	Unsatisfied and tired	Neutral or just OK	Satisfied and well Rested	Well rested, satisfied, and re-energized
<b>I feel...</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**19. With your consent, have you ever been diagnosed with the following?**

	Yes	No	Unsure
Hypertension (e.g. high blood pressure)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
High Cholesterol	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pre-Diabetic	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Diabetic	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Heart Disease	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Metabolic Syndrome	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Asthma	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Arthritis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Anxiety	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Depression	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hypothyroidism	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Major Depressive Disorder	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Coronary Atherosclerosis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Any behavioral disorder (e.g. Bipolar, Schizophrenia, etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Any rare medical condition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**20. What have you eaten/drunk today? (Please be as detailed as possible)**

**21. Have you performed any strenuous activity (exercise, cardio, work) for more than 30 minutes? If so please describe.**

## APPENDIX D

### University of Texas at El Paso (UTEP) Institutional Review Board Informed Consent Form for Research Involving Human Subjects

**Protocol Title:** Vascular Health and Brain Functioning: The Association of Arterial Stiffness with Cerebral Hemodynamic Response and Inhibitory Control

**Principal Investigator:** John Capps

**UTEP Department of Psychology**

In this consent form, “you” always means the study subject. If you are a legally authorized representative, please remember that “you” refers to the study subject.

**Introduction** You are being asked to take part voluntarily in the research project described below. You are encouraged to take your time in making your decision. It is important that you read the information that describes the study. Please ask the study researcher or the study staff to explain any words or information that you do not clearly understand.

**Why is this study being done?** Determine the relationship between vascular health factors, brain response, and cognitive performance

Approximately, 50 individuals will be enrolling in this study at UTEP.

You are being asked to be in the study because you expressed interested in participation and have indicated that you are do not have any know skin allergies, have never had a significant head injury, and not taking any medication, supplements or illicit substances which may affect your performance. If you decide to enroll in this study, your involvement will last about one hour for one session.

**What is involved in the study?** If you agree to take part in this study, the research team will: measure your body fat percentage using a BodPod machine, measure your blood pressure, measure pulse wave velocity using ECG sensors and a tonometer against your pulse in your neck and guide you while completing computerized tasks.

**You will:** have you complete an electronic questionnaire, have health metrics measured including body fat percentage using a BodPod machine, blood pressure, pulse wave velocity and then complete 2 computerized tasks while wearing a brain scanning headband.

**What are the risks and discomforts of the study?** The risks associated with this research are no greater than those involved in daily activities. There are no known or anticipated risks or discomforts associated with participation.

**What will happen if I am injured in this study?** The University of Texas at El Paso and its affiliates do not offer to pay for or cover the cost of medical treatment for research related illness or injury. No funds have been set aside to pay or reimburse you in the event of such injury or illness. You will not give up any of your legal rights by signing this consent form. You should report any such injury to John Capps at (910)274-1443 and to the UTEP Institutional Review Board (IRB) at (915-747-7693) or [irb.orsp@utep.edu](mailto:irb.orsp@utep.edu).

**Are there benefits to taking part in this study?**



You are not likely to benefit by taking part in this study. You will be provided with data you're your health measurements which are not clinically reliable but may help inform you and your doctor about current health which may need to be assessed by your primary care physician. This research may help us to aid in establishing that cerebral hemodynamic response (cerebrovascular reserve- the ability for cerebral blood vessels to respond to a need) as a mechanism linking overall vascular health and cognitive performance. Likewise, these findings will aid in future studies establishing the technique of combined fNIRS monitoring and cognitive testing as a clinical tool to measure cerebrovascular reserve.

**What are my costs?**

There are no direct costs.

**Will I be paid to participate in this study?**

You will be compensated for your participation in the form of \$15 Walmart gift card.

**What other options are there?**

You have the option not to take part in this study. There will be no penalties involved if you choose not to take part in this study.

**What if I want to withdraw, or am asked to withdraw from this study?**

Taking part in this study is voluntary. You have the right to choose not to take part in this study. If you do not take part in the study, there will be no penalty or loss of benefit. If you choose to take part, you have the right to skip any questions or stop at any time. However, we encourage you to talk to a member of the research group so that they know why you are leaving the study. If there are any new findings during the study that may affect whether you want to continue to take part, you will be told about them. The researcher may decide to stop your participation without your permission, if he or she thinks that being in the study may cause you harm.

**Who do I call if I have questions or problems?**

You may ask any questions you have now. If you have questions later, you may call John Capps at (910)274-1443, [jwcapps@miners.utep.edu](mailto:jwcapps@miners.utep.edu) If you have questions or concerns about your participation as a research subject, please contact the UTEP Institutional Review Board (IRB) at (915-747-7693) or [irb.orsp@utep.edu](mailto:irb.orsp@utep.edu).

**What about confidentiality?** Your part in this study is confidential. The following procedures will be followed to keep their personal information confidential. You will be assigned an arbitrary number in order to link your questionnaires with your other data. The results of this research study may be presented at meetings or in publications; however, your name will not be disclosed in those presentations. All records will be stored locally on password protected computers and in locked filing cabinets. The room containing both the computers and filing cabinets will be locked and only be accessible by the researchers.

**Mandatory reporting** If information is revealed about child abuse or neglect, or potentially dangerous future behavior to others, the law requires that this information be reported to the proper authorities.



# APPENDIX E

## Raw Light Processing Script

```
////////////////////////////////////
//  fnirSoft script
//  fNIRS script for refining raw light data
//  Date created: 4/8/2019 6:14:09 AM
//
fs.Lightgraph.Refine(lightgraph1 method.fir)
fs.Lightgraph.Refine(lightgraph1 method.ambient use.refined)
fs.Lightgraph.Refine(lightgraph1 method.smar use.refined)
```

## Oxygenation Data Processing Script

```
////////////////////////////////////
//
//  fnirSoft script
//  fNIRS script for refining oxygenation data
//  Author: John Capps
//  Date created: 4/8/2019 6:30:54 AM
//
Oxygraph.Refine(oxygraph1 method.detrending);
Oxygraph.Refine(oxygraph1 method.cbsi use.refined);
```

## Data Extraction Processing Script

```
////////////////////////////////////
//
//  fnirSoft script
//  fNIRS script for extracting block variables
//  Author: John Capps
//  Date created: 4/10/2019 8:30:54 AM
//
//GO/NO-GO TASK
//Extract HBO/HBR DATAS
HBO.GNG.LV = Temporal.MeanAcross( Temporal.MeanWithin( Find( "hbo.Block" "GNG" )))
HBO.GNG.SD = Temporal.MeanAcross( Temporal.StdWithin( Find( "hbo.Block" "GNG" )))
HBO.GNG.Min = Temporal.MeanAcross( Temporal.MinWithin( Find( "hbo.Block" "GNG" )))
HBO.GNG.Max = Temporal.MeanAcross( Temporal.MaxWithin( Find( "hbo.Block" "GNG" )))

HBR.GNG.LV = Temporal.MeanAcross( Temporal.MeanWithin( Find( "hbr.Block" "GNG" )))
HBR.GNG.SD = Temporal.MeanAcross( Temporal.StdWithin( Find( "hbr.Block" "GNG" )))
HBR.GNG.Min = Temporal.MeanAcross( Temporal.MinWithin( Find( "hbr.Block" "GNG" )))
HBR.GNG.Max = Temporal.MeanAcross( Temporal.MaxWithin( Find( "hbr.Block" "GNG" )))
//HBO Trim to only middle 4 optodes
//HBO MEAN
HBO.GNG.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBO.GNG.LV"))
HBO.GNG.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBO.GNG.FR" ))))))))
F4.HBO.GNG = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBO.GNG.FR1" ))))))))
//HBO-SD
HBO.GNG.SD.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBO.GNG.SD"))
HBO.GNG.SD.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBO.GNG.SD.FR" ))))))))
F4.HBO.GNG.SD = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBO.GNG.SD.FR1" ))))))))
//HBO-MIN & MAX
HBO.GNG.MIN.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBO.GNG.Min"))
HBO.GNG.MIN.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBO.GNG.min.FR" ))))))))
F4.HBO.GNG.MIN = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBO.GNG.MIN.FR1" ))))))))

HBO.GNG.MAX.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find( name "HBO.GNG.Max"))
HBO.GNG.Max.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBO.GNG.Max.FR" ))))))))
F4.HBO.GNG.MAX = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBO.GNG.Max.FR1" ))))))))
//HBR Trim to only middle 4 optodes
//HBR MEAN
HBR.GNG.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBR.GNG.LV"))
HBR.GNG.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBR.GNG.FR" ))))))))
F4.HBR.GNG = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBR.GNG.FR1" ))))))))
//HBR-SD
HBR.GNG.SD.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBR.GNG.SD"))
HBR.GNG.SD.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBR.GNG.SD.FR" ))))))))
F4.HBR.GNG.SD = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBR.GNG.SD.FR1" ))))))))

//HBR-MIN & MAX
HBR.GNG.MIN.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBR.GNG.Min"))
HBR.GNG.MIN.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBR.GNG.min.FR" ))))))))
F4.HBR.GNG.MIN = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBR.GNG.MIN.FR1" ))))))))

HBR.GNG.MAX.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find( name "HBR.GNG.Max"))
HBR.GNG.Max.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBR.GNG.Max.FR" ))))))))
F4.HBR.GNG.MAX = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBR.GNG.Max.FR1" ))))))))

//STOP SIGNAL TASK
//Extract HBO/HBR DATAS
HBO.SST.LV = Temporal.MeanAcross( Temporal.MeanWithin( Find( "hbo.Block" "SST" )))
HBO.SST.SD = Temporal.MeanAcross( Temporal.StdWithin( Find( "hbo.Block" "SST" )))
HBO.SST.Min = Temporal.MeanAcross( Temporal.MinWithin( Find( "hbo.Block" "SST" )))
HBO.SST.Max = Temporal.MeanAcross( Temporal.MaxWithin( Find( "hbo.Block" "SST" )))
```

```

HBR.SST.LV = Temporal.MeanAcross( Temporal.MeanWithin( Find( "hbr.Block" "SST" )))
HBR.SST.SD = Temporal.MeanAcross( Temporal.StdWithin( Find( "hbr.Block" "SST" )))
HBR.SST.Min = Temporal.MeanAcross( Temporal.MinWithin( Find( "hbr.Block" "SST" )))
HBR.SST.Max = Temporal.MeanAcross( Temporal.MaxWithin( Find( "hbr.Block" "SST" )))
//HBO Trim to only middle 4 optodes
//HBO MEAN
HBO.SST.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBO.SST.LV"))
HBO.SST.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBO.SST.FR"))))))))
F4.HBO.SST = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBO.SST.FR1"))))))))
//HBO-Sd
HBO.SST.SD.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBO.SST.SD"))
HBO.SST.SD.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBO.SST.SD.FR"))))))))
F4.HBO.SST.SD = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBO.SST.SD.FR1"))))))))
//HBO-MIN & MAX
HBO.SST.MIN.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBO.SST.Min"))
HBO.SST.MIN.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBO.SST.min.FR"))))))))
F4.HBO.SST.MIN = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBO.SST.MIN.FR1"))))))))

HBO.SST.MAX.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBO.SST.Max"))
HBO.SST.Max.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBO.SST.Max.FR"))))))))
F4.HBO.SST.MAX = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBO.SST.Max.FR1"))))))))
//HBR Trim to only middle 4 optodes
//HBR MEAN
HBR.SST.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBR.SST.LV"))
HBR.SST.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBR.SST.FR"))))))))
F4.HBR.SST = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBR.SST.FR1"))))))))

//HBR-Sd
HBR.SST.SD.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBR.SST.SD"))
HBR.SST.SD.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBR.SST.SD.FR"))))))))
F4.HBR.SST.SD = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBR.SST.SD.FR1"))))))))
//HBR-MIN & MAX
HBR.SST.MIN.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBR.SST.Min"))
HBR.SST.MIN.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBR.SST.min.FR"))))))))
F4.HBR.SST.MIN = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBR.SST.MIN.FR1"))))))))

HBR.SST.MAX.FR = Spatial.Reject( [1 2 3 4 5 6 11 12 13 14 15 16] Find(name "HBR.SST.Max"))
HBR.SST.Max.FR1 = Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Spatial.TrimFirst( Find(name "HBR.SST.Max.FR"))))))))
F4.HBR.SST.MAX = Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Spatial.TrimLast( Find(name "HBR.SST.Max.FR1"))))))))

//Compile and Export
//Compile Datas to ARRAYS
DataGNG = [F4.HBO.GNG F4.HBO.GNG.SD F4.HBO.GNG.MIN F4.HBO.GNG.MAX F4.HBR.GNG F4.HBR.GNG.SD F4.HBR.GNG.MIN F4.HBR.GNG.MAX]
DataSST1 = [F4.HBO.SST F4.HBO.SST.SD F4.HBO.SST.MIN F4.HBO.SST.MAX F4.HBR.SST F4.HBR.SST.SD F4.HBR.SST.MIN F4.HBR.SST.MAX]
//Compile Datas to VECTOR
Alldata = [DataGNG DataSST1]
//Export to Datafile
Export2csv ("compileddataHC#" Alldata)

```

## CURRICULUM VITA

John Capps earned his Bachelor of Arts with honors in Psychology from the University of North Carolina at Wilmington (UNCW) in 2014. During that time, he also completed minors in biology, chemistry, and neuroscience and was recipient of multiple awards including the Cape Fear Psychological Association Award. At UNCW, he worked under Antonio E. Puente Ph.D. in the UNCW Neuropsychology laboratory, in his private practice, and at Cape Fear Clinic (serving uninsured patients). His research under Puente focused on military and cross-cultural neuropsychology. Likewise, during this time, John worked under Karen Daniels, Ph.D. and Jeffery Toth, Ph.D. in the Aging and Cognitive Training laboratory focusing on the influence of health on cognitive functioning and neuroimaging using function near infrared spectroscopy (fNIRS).

In 2015, John entered the doctoral program in Psychology at the University of Texas at El Paso. While at UTEP John has worked in the Health Applied Psychometrics and JDM laboratory under the direction of Osvaldo Morera, Ph.D. His research has focused on the influence of health on brain hemodynamics and brain functioning. John was awarded the Dodson grant as well as several travel grants. Furthermore, John also works as part of the “Investigación Interdisciplinaria en Ciencias de Salud” group at Universidad Autónoma de Ciudad Juárez (UACJ). John has coauthored articles such as, “Cravings, sugar and fat consumption as determinant factors of obesity in young adults in Juarez City” published in *Nutricion hospitalaria* and “Daily stress and coping strategies: Relationships with anxiety and resilience in preadolescents from Ciudad Juarez, Mexico” published in *Current Psychology*. Likewise, John has co-authored a chapter titled, “Omega-3 and Cognition in Children with Malnutrition” as part of the book, *Omega Fatty Acids in Brain and Neurological Health* 2<sup>nd</sup> edition.

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