Clark et al., J Food Nutr Disor 2013, 2:2
http://dx.doi.org/10.4172/2324-9323.1000107

Journal of Food & Nutritional Disorders

Research Article

A SCITECHNOL JOURNAL

Cognitive Skills and BMI on Cardiovascular Responses to Stress

Vernessa R Clark[1]*, Kimberly Boyd Starke[1], Oliver W Hill Jr.[1] and Zewelanji Serpell[1]

Abstract

The present study examined the effects of cognitive skills (processing speed, visual memory and auditory memory) and body mass index (BMI) on cardiovascular responses to stress. It was hypothesized that obese participants who score lower on measures of cognitive skills would have greater cardiovascular responses to the stressor than normal weight participants higher scores on the cognitive skills. The participants for the study were 97 African American college students between the ages of 18-27. BMI ranged from 15.60-47.10 kg/m^2 and the mean BMI was 26.47 kg/m^2. Cognitive skills were taken from a battery that is being developed as the Gibson Cognitive Skills Test. The cognitive skills used in the present study were processing speed, visual memory and auditory memory. Cardiovascular measures were taken as the participants viewed a racially noxious scene on videotape. The scene depicted the horrendous conditions that Africans experienced, as they were transported to America for slavery. Findings from the study revealed that individuals with lower cognitive skill levels and higher BMIs had higher blood pressures and blood output than their counterparts. This project expands our knowledge of cardiovascular responses to stress, by examining the influence of cognition in the process. A continuation of this research would assist with providing a deeper understanding of the impact of cognition on obesity and cardiovascular disease.

Keywords

Cognitive skills; Cardiovascular activity; BMI

Introduction

Cognitive skills and bmi on cardiovascular responses to stress

Health disparities continue to rise for African Americans in numerous categories of well-being, including cardiovascular health [1]. In an attempt to reduce these disparities, compounding relationships such as obesity and cardiovascular disease must be addressed. Researchers have begun to investigate potential pathways that may assist with understanding these relationships/linkages [2-5]. Since studies have shown that lower cognitive skill levels may be a risk factor for cardiovascular disease, a subsequent logical pathway includes an investigation of cognitive functioning on cardiovascular disease. Power et al. [6] examined the association of childhood cognition as a risk factor for cardiovascular disease in mid-adulthood. They found that participants with lower levels of general cognitive ability during childhood, had higher systolic and diastolic blood pressures and greater triglyceride levels in mid adulthood than those with higher levels of general cognition. Similarly, Brown et al. [7] examined cognitive functioning and blood pressure reactivity to a Perception of Affect Task. After adjusting for age, education and baseline blood pressure levels, diastolic blood pressure was associated with poorer performance on verbal learning and memory and attention tests.

Other researchers have found that poor cognitive skills are more associated with cardiac functioning than vascular functioning. Zheng et al. [8] found that declines in global cognition, verbal memory and executive function had strong associations with coronary artery disease, but not vascular risk factors (i.e. hypertension) in 74 cognitively normal (clinical dementia score of 0) participants 55 years of age and older. In addition, Ginty et al. [9] examined the association of future cognitive ability and cardiovascular reactivity to an acute laboratory mental challenge in a sample of 1647 men and women from Glasgow, Scotland. The investigators found that poor levels of cognitive ability were associated with low levels of heart rate reactivity. Blood pressure reactivity to the task was not associated with cognitive ability.

It is clear that a relationship between cognition and physiological activity exists, yet studying heart rate and blood pressure alone does not provide a clear understanding of the underlying mechanisms of this relationship. Examining blood output (stroke volume and cardiac output) may help to elucidate the relationship between cognitive abilities and blood pressure. To this end, the present study examined the effects of cognitive skills on stroke volume and cardiac output, as well as blood pressure responses to stress.

Cognition and obesity

A considerable number of studies suggest that obesity is related to cognitive decline in midlife [10]. Power et al. [6] found that participants with lower levels of general cognitive ability during childhood had higher body mass index and waist circumference levels in mid adulthood, than those with higher levels of general cognition. While most studies that found an association of obesity and cognitive abilities examined this relationship in adults, Yau et al. [11] examined the relationship between obesity and cognitive impairments in adolescents. The investigators found that children with metabolic syndrome (high levels of obesity) had lower arithmetic and spelling skills, and overall lower intelligence than their lower weight counterparts.

Delgado-Rico et al. [12] found that effective cognitive strategies may reduce the perilous effects of obesity. The investigators investigated the effects of a behavioral intervention on cognitive deficits in overweight adolescents, and found that improvement in cognitive inhibitory control skills were associated with a reduction in BMI and cholesterol levels. The authors concluded that effective cognitive inhibitory control strategies are vital components of obesity treatment programs.

*Corresponding author: Vernessa R. Clark, Department of Psychology, Virginia State University, Petersburg, Virginia 23806, USA, Tel: 804-524-5940; E-mail: vrclark@vsu.edu

Received: November 22, 2012 **Accepted:** April 03, 2013 **Published:** April 08, 2013 doi:http://dx.doi.org/10.4172/2324-9323.1000107

While African Americans have one of the highest rates of obesity, few studies have examined the relationship between obesity and cognitive abilities in African Americans. Therefore, the present study examined the effects of cognitive skills and BMI on cardiovascular to a racial stressor in African American college students. It was hypothesized that BMI would have a significant effect on cardiovascular responses. Specifically, obese participants would have greater cardiovascular responses to the stressor than their normal weight and overweight counterparts. It was also hypothesized that participants with lower cognitive skills would have greater blood output and vascular responses to the stressor than participants with more highly developed cognitive skills. Lastly, it was hypothesized that obese participants with lower cognitive skills would have the greatest cardiovascular responses to the stressor.

Methods

Participants

Ninety seven African American college students (76 women, 21 men), between the ages of 18-27 (mean=19.79) participated in the study. Students who were under the age of 18, and/or had cardiovascular related disorders (*i.e.* hypertension, diabetes) were not allowed to participate**.** Fifty four of the participants were of normal weight, 19 were overweight and 24 were *obese.* Of the obese participants, 6 participants were categorized as class II obese (>35-39.9), and 4 were categorized as class III obese (>40). BMI ranged from 15.60-47.10, and the mean BMI was 26.47. All participants were citizens of the United States and were recruited from a University in the Southeast. The participants volunteered to be in the study and were treated in accordance to the American Psychological Association ethical guidelines. The University's Institutional Review Board approved the study protocol.

Materials and apparatus

A Hypertension Diagnostic Pulse wave CR 2000 cardiovascular profiling instrument was used to measure heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, stroke volume and cardiac output. The oscillometric method determined the mean arterial pressure, as well as systolic and diastolic blood pressure. In addition, cardiac ejection time measured from blood pressure waveforms were used to obtain measures of heart rate, stroke volume and cardiac output. This device is a well-established method of assessing cardiovascular activity, and has been used in previous studies [3,4].

Psychological stressor

Cardiovascular measures were taken as the participants viewed a racially noxious scene on videotape. The scene depicted the horrendous conditions that Africans experienced as they were transported to America for slavery. Prior to viewing the scene, the participants were told that they would view a videotape, but were not given any details on the videotape. The scene has been used as an emotional arousal in a previous study [3]. Clark et al. [3] found that BMI and waist circumference significantly predicted systolic blood pressure, stroke volume and cardiac output prior to, during, and after the emotionally arousing scene.

Body mass index

Body mass index was measured by using body weight and height measured on a Seca Column scale. Body mass index was classified into three categories, based on the guidelines of the Department of Health and Human Services. The categories: normal weight (BMI of 18.5-24.9 kg/m^2); overweight (BMI of 25-29.9 kg/m^2); and obese (BMI of 30 kg/m^2 or greater).

Cognitive skills tasks

Cognitive skills were assessed with a set of cognitive tasks. These cognitive tasks were taken from a battery that is being developed as the Gibson Cognitive Skills Test. While initial tests of reliability have been shown to be adequate (Kiplinger, 2008), the psychometric properties of this test are still being established. We, therefore, used raw task performance as our dependent measures.

Processing speed

The participants were asked to locate and click on one of two identical numbers/letters in a row of six targets projected on a computer screen. The task increased in difficulty from single digit/letter to triple digit/letter combinations. Participants were instructed to respond as quickly as possible. Five practice trials were given, followed by fifty experimental trials. If more than two incorrect responses were given during the practice trials, the instructions and practice trials were repeated. The score was the total task time.

Memory

Aspects of memory were assessed by a task that consisted of five audio statements, each of which was accompanied by a picture. After each set was presented, a total of twenty questions were asked. The questions referred to earlier statements or pictures, so participants were instructed to pay close attention and retain the information over the entire test. Auditory and visual memory scores were obtained by correct responses to questions about information presented in each of those modalities.

Procedure

Data were collected during two sessions, a physiological session and a cognitive session. In the physiological session, cardiac output, stroke volume, heart rate, mean arterial pressure and diastolic and systolic blood pressures were measured as the participants viewed the stressful scene. To take these measures, a blood pressure cuff was placed on the left arm and an arterial sensor was placed on the pulse on the wrist of the right hand. Measurements were taken before the scene (pre-stressor period), as the participants viewed the scene (stressor period), and after the scene (recovery period). Each period lasted three minutes, with measurements taken forty seconds into each period. During the cognitive session, participants completed the computerized cognitive skills tasks. Half the participants viewed the scene prior to performing these tasks, and half viewed the scene after the cognitive tasks.

Results

A multivariate analysis of variance (MANOVA) was conducted to examine the effects of scores on the cognitive tasks (high, moderate, low) and BMI (normal, overweight and obese) on each cardiovascular measure. High, moderate and low cognitive task scores are normative, based on this sample divided in thirds. The Statistical Package for the Social Sciences computer program was used to conduct all data analyses. The overall model was significant for all main effects and cognitive skill/BMI interaction effects, except one (Table 1). Due to

doi:http://dx.doi.org/10.4172/2324-9323.1000107

the difficulty in interpretation, three and four way interactions were not included in the analysis. Means for all study variables are in table 2.

Cognitive skills and cardiovascular activity

It was hypothesized that participants with more highly developed cognitive functioning would have less cardiovascular responses to the racial stressor. The univariate ANOVA's from the analysis revealed that processing speed had a significant effect on diastolic blood pressure during the pre-stressor $F(2,88)=3.46$, $p<.05$ period. In addition, processing speed significantly affected mean arterial pressure during the stressor, $F(2,88)=4.31$, $p<.05$ and recovery periods, $F(2,88)=3.60$, $p<.05$. Visual memory significantly affected stroke volume during the pre-stressor $F(2,88)=6.72$, $p< .05$, stressor $F(2,88)=5.76$, $p<.05$ and recovery $F(2,88) = 5.58$, $p< .05$ periods. Visual memory also had a significant effect on systolic blood pressure during the pre-stressor, $F(2,88)=3.50$, $p<.05$ and stressor, $F(2,88)=5.68$, $p<.05$ periods and heart rate during the pre-stressor, $F(2,88)=7.84$, $p<.05$ and recovery periods, $F(2,88)=5.21$, $p<.05$ (Table 3). These findings indicate that participants with the lowest level of cognitive efficiency were more emotionally aroused by the scene than their higher scoring counterparts.

BMI and cardiovascular activity

The hypothesis that obese participants would have greater cardiovascular responses to the stressor than their normal weight and overweight counterparts was supported. The univariate ANOVA's also revealed that BMI had a significant effect on cardiac output during the pre-stressor F $(2,88)=19.65$, $p<.01$, stressor $F(2,88)=22.80$, $p<.01$ and recovery $F(2,88)=17.86$, $p<.01$ periods. BMI also had a significant effect on stroke volume during the pre-stressor $F(2,88)=5.04$, $p<.05$ and stressor $F(2,88)=3.47$, $p<.05$ periods (Table 4). Obese participants had significantly greater blood output than their counterparts.

Table 1: Wilks' lambda values for main and interaction multivariate effects.

Wilks' Lambda	*dfp*		
Processing speed	.80	36	.019
Visual memory	.070	36	.010
Auditory memory	.083	36	.022
BMI	.051	36	.002
Processing speed * BMI	.013	72	.065
Visual memory * BMI	.009	72	.003
Auditory memory * BMI	.039	54	.040

Table 2: Means and standard deviations for all study variables.

	Means	Standard Deviations
BMI	26.45	6.48
Processing speed	35.52	8.05
Visual memory	9.94	1.78
Auditory memory	9.94	1.98
Heart rate (bpm)*	72.50	10.35
Diastolic blood pressure (mm Hg)*	63.42	7.62
Systolic blood pressure (mm Hg)*	115.86	10.60
Stroke volume (mL)*	78.37	15.08
Cardiac output (L/mm)*	5.68	.83
Body mass index (kg/m^2)	26.48	6.47

*Collapsed across periods.

Table 3: Mean cognitive skills and cardiovascular activity.

Visual memory			
	High	Medium	Low
Systolic blood pressure pre-stressor*	112.8 (2.1)**	13.1(2.0)	116.9 (1.5)
Systolic blood pressure stressor	109.4 (2.1)	12.7 (2.0)	117.1 (1.6)
Heart rate pre-stressor	76.0 (2.5)	66.8 (2.4)	68.9 (1.9)
Heart rate recovery	76.5 (2.5)	71.9 (2.4)	67.0 (1.8)
Stroke volume pre-stressor	68.5 (3.0)	79.5 (2.9)	84.9 (2.2)
Stroke volume stressor	73.8 (3.1)	78.9 (2.9)	88.4 (2.3)
Stroke volume recovery	70.8 (3.0)	80.3 (2.9)	84.7 (2.2)
Processing speed			
Diastolic blood pressure pre-stressor	68.1 (1.8)	61.6 (1.3)	62.6 (1.3)
Mean arterial pressure stressor	84.2 (1.9)	77.7 (1.3)	80.9 (1.3)
Mean arterial pressure recovery	83.2 (1.7)	77.9 (1.6)	83.2 (1.7)

*All means are significant at the p<.05 level
** Standard errors are in parentheses

Pre-stressor-Pre-stressor period
Stressor-Stressor period
Recovery-Recovery period

Table 4: Mean BMI and cardiovascular responses to stress.

	Normal	Overweight	Obese
Cardiac output pre-stressor*	5.09 (.104)**	5.56 (.151)	6.52 (.158)
Cardiac output stress	5.19 (.093)	5.55 (.135)	6.05 (.142)
Cardiac output recovery	5.16 (.098)	5.55 (.143)	6.35 (.150)
Stroke volume pre-stressor	74.40 (2.09)	78.76 (3.05)	87.11 (3.19)
Stroke volume stress	77.33 (2.14)	83.77 (3.11)	86.42 (3.3)

*All means are significant at the p ≤ .05
**Standard errors are in parentheses

Pre-stressor-Pre-stressor period
Stressor-Stressor period
Recovery-Recovery period

Cognitive skills, BMI and cardiovascular activity

BMI significantly interacted with processing speed for mean arterial pressure during the pre-stressor period $F(4,88)=3.18$, $p<.05$ and cardiac output during the stressor period $F(4,88)=3.10$, $p<.05$. The findings showed that normal weight participants with moderate levels of processing speed had the lowest mean arterial pressure, and obese participants with the highest levels of processing speed had the highest mean arterial pressure. BMI also significantly interacted with visual memory for heart rate during the pre-stressor period $F(4,88)=6.38$, $p<.05$. Obese participants with the lowest levels of visual memory had the highest heat rates, and overweight participants with moderate levels of visual memory had the lowest heart rates. The univariate ANOVA's also revealed a significant interaction between BMI and auditory memory for systolic blood pressure during the pre-stressor, $F(4,88)=4.00$, $p<.05$ and recovery, $F(4,88)=3.53$, $p<.05$ periods, and diastolic blood pressure during the pre-stressor period, $F(4,88)=3.61$ $p<.05$ and mean arterial pressure during the pre-stressor period, $F(4,88)=3.47$, $p<.05$ (Tables 5 and 6). These findings showed that obese participants with the lowest level of auditory memory levels had the highest blood pressures, and normal weight participants with the highest levels of auditory memory had the lowest blood pressures.

Discussion

The first major finding showed that processing speed and visual memory had a significant effect on diastolic blood pressure, systolic blood pressure and stroke volume. Specifically, participants with low levels of cognitive efficiency had higher blood pressures and less blood output than their counterparts. The association of cognitive functioning and cardiovascular responses to stress may be attributed to smaller cerebral blood flow responses. Blood output affects blood pressure by increasing/decreasing the amount of blood flowing through the veins, and increased blood pressure leads to the constriction of cerebral blood vessels [13]. According to Waldstein [13], adequate cerebral blood flow responses are necessary for efficient cognitive functioning, and increases in blood pressure are associated with decreases in cerebral blood flow.

Table 5: Means for auditory memory and BMI interactions.

Systolic blood pressure pre-stressor period		
Low auditory memory	**Mean**	**Std. Error**
Normal weight	113.0	2.38
Overweight	112.7	4.39
Obese	125.3	3.61
Moderate auditory memory		
Normal weight	110.0	2.23
Overweight	113.2	2.88
Obese	119.9	3.27
High auditory memory		
Normal weight	109.4	2.89
Overweight	121.0	4.17
Obese	114.0	5.11
Systolic blood pressure recovery period		
Low Auditory memory	Mean	Std. error
Normal weight	111.1	2.18
Overweight	117.3	4.02
Obese	125.1	3.30
Moderate auditory memory		
Normal weight	110.4	2.04
Overweight	114.5	2.63
Obese	118.5	2.98
High auditory memory		
Normal weight	111.3	2.65
Overweight	114.8	3.18
Obese	114.8	4.60
Diastolic blood pressure pre-stressor period		
Low auditory memory	**Mean**	**Std. error**
Normal weight	64.3	1.85
Overweight	69.3	3.41
Obese	68.1	2.81
Moderate auditory memory		
Normal weight	60.1	1.73
Overweight	61.4	2.24
Obese	67.9	2.54
High auditory memory		
Normal weight	59.8	2.25
Overweight	65.3	3.24
Obese	58.5	3.97
Mean arterial pressure pre-stressor		
Low auditory memory	Mean	Std. error
Normal weight	80.5	1.97
Overweight	83.2	3.64
Obese	86.0	12.99
Moderate auditory memory		
Normal weight	79.0	1.84
Overweight	82.5	2.38
Obese	84.5	2.70
High auditory memory		
Normal weight	74.97	2.39
Overweight	85.5	3.45
Obese	79.25	4.22

Table 6: Significant means for visual memory, processing speed and bmi interactions.

Heart rate pre-stressor		
Low visual memory	**Mean**	**Std. error**
Normal weight	71.8	3.5
Overweight	73.9	4.4
Obese	93.0	6.2
Moderate visual memory		
Normal weight	72.2	3.3
Overweight	52.4	5.0
Obese	73.0	4.7
High visual memory		
Normal weight	64.9	2.4
Overweight	72.1	3.9
Obese	71.4	3.7
Mean arterial pressure pre-stressor		
Low processing speed	Mean	Std. error
Normal weight	88.0	2.8
Overweight	83.2	3.5
Obese	84.0	3.3
Moderate processing speed		
Normal weight	76.2	1.6
Overweight	86.6	3.2
Obese	77.1	3.1
High processing speed		
Normal weight	77.1	2.1
Overweight	81.6	2.5
Obese	88.5	2.9
Cardiac output stressor		
Low processing speed	**Mean**	**Std. error**
Normal weight	5.4	.22
Overweight	5.5	.27
Obese	6.8	.25
Moderate processing speed		
Normal weight	5.2	.27
Overweight	5.2	.25
Obese	6.2	.24
High processing speed		
Normal weight	5.1	.16
Overweight	5.9	.19
Obese	6.5	.23

The second major finding revealed that BMI significantly affected cardiac output and stroke volume responses to the stressor. The heart of obese participants pumped significantly more blood than their lower weight counterparts. Similar findings were reported by Clark et al. [3] and Clark and Hill [4], who found that BMI was associated with cardiac output and stroke volume responses to a racial stressor. The need for obese participants' hearts to pump and circulate greater amounts of blood may account for the positive associations between BMI and blood output.

doi:http://dx.doi.org/10.4172/2324-9323.1000107

The most interesting finding revealed an interaction between cognitive skills and BMI on cardiovascular responses. Overall, obese participants with the lowest levels of visual and auditory memory had the highest blood pressures, and normal weight participants with the highest levels of these cognitive skills had the lowest blood pressures. The findings suggest that poor cognitive skills were associated with attenuated blood pressure responses to the stressor and may act as a mediator of BMI and cardiovascular responses to stress. In the study, the participants with low levels of cognitive skills were more physiologically aroused by the stressor than participants with high levels of cognitive skills. Similar results were reported by McNay et al. [14], who found that a high-fat diet negatively impacted basal cognitive function and weakened both cognitive and metabolic responses to hippocampal insulin in rodents with type 2 diabetes. According to Shoblom [15], one possible reason for the association of cognitive function and obesity is leptin, an appetite suppressing hormone that also enhances cognitive development. The investigators reported that rejection of leptin resulted in decreased cognitive functioning in obese children and adults. Further research in this area should assist with a better understanding of the interaction of leptin and specific cognitive skills on cardiovascular responses.

Limitations of the Study

The findings of the present study are limited to the responses to a racial stressor. Future studies should examine the effects of BMI and cognitive functioning on cardiovascular responses to a general non-racial stressor. Another limitation of the study was that central adiposity and waist-to-hip ratio were not measured. Both central adiposity and waist-to-hip ratio are risk factors for cardiovascular disease, and may also influence the way the cardiac and vascular systems react to stress. Future studies should examine the effects of these two measures of obesity on cardiovascular reactivity to stress.

Acknowledgement

This research study was partially supported by National Science Foundation grant DRL-0929779.

References

1. CDC (2011) Eliminate Disparities in Cardiovascular Disease (CVD). CDC, USA.
2. Rozanski A, Blumenthal JA, Kaplan J (1999) Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy. Circulation 99: 2192-2217.
3. Clark V, Greenberg B, Harris T, Carson B (2012) Body mass index and waist circumference predictors of cardiovascular risk in African Americans. Ethn Dis 22: 162-167.
4. Clark V, Hill O (2009) Body mass and cardiovascular reactivity to racism in African American college students. Ethn Dis 19: 2-6.
5. Clark V, Moore C, Adams J (1998) Cholesterol concentrations and cardiovascular reactivity to stress in African American college volunteers. J Behav Med 21: 505-515.
6. Power C, Jefferis B, Manor O (2010) Childhood cognition and risk factors for cardiovascular disease in midadulthood: The 1958 British birth cohort study. Am J Public Health 100: 129-136.
7. Brown J, Sollers J, Thayer J, Zonderman A, Waldstein S (2009) Blood pressure reactivity and cognitive function in the Baltimore longitudinal study of aging. Health Psychol 28: 641-646.
8. Zheng L, Mack W, Chui H, Heflin L, Mungas D, et al. (2012) Coronary artery disease is associated with cognitive decline independent of changes on magnetic resonance imaging in cognitively normal elderly adults. J Am Geriatr Soc 60: 499-504.
9. Ginty A, Phillips A, Der G, Deary I, Carroll D (2013) Heart rate reactivity is associated with future cognitive ability and cognitive change in a large community sample. Int J Psychophysiol 82: 167-174.
10. Dahl AK, Hassing LB (2013) Obesity and cognitive aging. Epidemiol Rev 35: 22-32.
11. Yau PL, Castro MG, Tagani A, Tsui WH, Convit A (2012) Obesity and metabolic syndrome and functional and structural brain impairments in adolescence. Pediatrics 130: 856-864.
12. Delgado-Rico E, Rio-Valle J, Abein-Urios N, Caracuel A, Gonzalez Jimenez E, et al. (2012) Effects of a multicomponent behavioral intervention on impulsivity and cognitive deficits in adolescents with excess weight. Behav Pharmacol 23: 609-615.
13. Waldstein SR (2003) The relation of hypertension to cognitive function. Curr Dir Psychol Sci 12: 9-12.
14. McNay EC, Ong CT, McCrimmon RJ, Cresswell J, Bogan JS, et al. (2010) Hippocampal memory processes are modulated by insulin and high-fat-induced insulin resistance. Neurobiol Learn Mem 93: 546-553.
15. Shoblom T (2011) Obesity's impact on cognitive development in children. Livestrong.com.

Author Affiliation

Top

[1]*Department of Psychology, Virginia State University, Petersburg, Virginia 23806, USA*