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Exploring the "Obesity Paradox" as a Correlate of Cognitive and Physical Function in Community-dwelling Black and White Older Adults

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Objective: The obesity paradox has been documented in aged populations, yet it remains unclear if this paradox persists for physical and cognitive outcomes in community-dwelling older adult populations. Our study examines associations between body mass index (BMI) classification, cognitive function, and physical function. We also investigate whether these associations are modified by race or age.

Design: Cross-sectional study.

Settings: Senior residential sites and community centers in Saint Louis, Missouri.

Participants: Study participants included 331 adults, aged >55 years. Age was stratified into young-old (aged 55-74 years) and older (aged ≥75 years).

Outcome Measures: Physical function was measured using the mini-Physical Performance Test (mini-PPT) and grip strength. Cognitive function was assessed with the Short Blessed Test (SBT) and the Trail Making Tests (TMT-A and TMT-B) performance.

Results: Older adults who were obese had significantly better cognitive flexibility (TMT-B) performance than normal weight older adults (P=.02), and this association was not influenced by age or race. Adiposity was not associated with psychomotor speed (TMT-A), general cognition (SBT), or measures of physical function (Ps>.05).

Conclusion: In a diverse sample of community-dwelling older adults, we found partial support for the controversial obesity paradox. Our results suggest excess adiposity may be protective for executive function processes. Future research is needed to examine the underlying physiological processes linking adiposity to executive function in older adults. *Ethn Dis.* 2017;27(4):387-394; doi:10.18865/ed.27.4.387.

Keywords: Race; Body Mass Index; Cognition; Physical Function

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In Memory

With heavy hearts, the co-authors would like to acknowledge the untimely death of our lead author, Dr. Jeannine Skinner.

We honor the life and service of Dr. Skinner who touched the lives of many with her kind spirit as a mentor, colleague, scientist, and advocate for social justice; her energy, grace, and enthusiasm will be truly missed.

Introduction

Excess adiposity as characterized by overweight status and obesity is a major public health problem for all segments of the US population, including older adults. Recent epidemiological reports show one third of US older adults are obese, with the highest rates of obesity among older adults aged 65-74 years.[1] Among ethno-racial groups, obesity is highest among older African Americans and Hispanic/Latinos. Differences in the prevalence of overweight status and obesity in these groups are a key contributor to racial and ethnic health disparities. Given the exponential growth of the minority older adult population and steady increase in overweight and obesity rates across the lifespan, it is important to improve our understanding of the association between excess adiposity and physical and cognitive health outcomes among different segments of the older adult population.

Physical function encompasses a range of functional abilities including activities of daily living and mobility tasks. Physical function is a robust predictor of clinical outcomes such as hospitalization and mortality.[2,3] Although excess adiposity in early life and adulthood has been linked to poorer physical function,[4] associations in late-life have yielded less consistent results.[5,6] Among aged populations, low body mass index (BMI), weight loss, and obesity are reported to be negatively associated with mobility, while overweight status may be protective against loss of mobility[7] and disability.[8] Researchers surmise that factors such as increased bone mineral density and decreased risk for fractures,[8,9] and muscle strength,[7] may be important underlying mechanisms contributing to this phenomenon. Moreover, evidence suggests the association between late-life adiposity and physical function may vary by race. For example, evidence suggests older African Americans experience reduced mobility at a heavier weight than older White adults.[10] African Americans and Whites differ in body fat and lean muscle composition[11,12] and this may explain, in part, studies showing a weaker association between adiposity and mobility in African American elders relative to White elders.

The aim of this study was to examine the relationship between weight classification, cognitive function and physical function, and to determine whether these associations were modified by race or stratified age in a sample of community-dwelling older adults.

Counterintuitive associations between adiposity and cognitive function are well-documented in aged populations. Several studies report late-life adiposity may confer cognitive benefits including better baseline cognitive function[13] and decreased risk for cognitive decline and dementia among heavier older adults.[14,15] Some studies describe a nonlinear relationship between adiposity and cognitive function, such that both low weight and obesity are associated with poorer cognitive function relative to overweight status,[13] while others do not.[14] Additional support comes from neurobiological studies reporting lower Alzheimer's disease neuropathology burden in overweight, non-demented and mild cognitive impairment (MCI) older adult populations.[16,17] It is important to note that this association may be modified by age and anthropometric measurement method[18] and not all studies provide evidence in support of the obesity paradox.[19-21] However, given the discrepancies in existing literature and the importance of cognitive and physical health in the maintenance of independent living abilities in late-life, it is important to clarify these complex associations.

The complex associations between late-life adiposity and physical and cognitive health have often been explained in the context of the obesity paradox. The obesity paradox describes an association between excess adiposity and favorable health outcomes.[22] This paradox has been reported in several aged, clinical populations including patients with coronary heart disease[23] and diabetes.[24] There is a paucity of research examining this phenomenon in non-patient, community-dwelling older adult populations. Moreover, the association between excess adiposity and health outcomes may vary by race,[25] obesity severity,[26] and cardiorespiratory fitness.[27] Researchers attempting to explain the obesity paradox have proposed several hypotheses. One explanation is that low weight may indicate weight loss and underlying pathology linked to declining general health and the development of dementia.[28,29] Another explanation proposes that excess adiposity confers more energy reserves and a stronger inflammatory response that may improve the body's ability to combat acute illness.[27] An additional argument asserts that in aged populations, BMI is a robust predictor of skeletal mass,[30] which is positively related to cognitive function.[31] Lastly, persons with excess adiposity may be treated more aggressively because they present with chronic health conditions earlier than persons of lower weight.[32] Collectively these explanations suggest that underlying mechanisms of the obesity paradox remain unclear and warrant further investigation.

Based on existing evidence, it remains unclear whether: a) the obesity paradox persists for physical and cognitive outcomes in non-patient, community-dwelling older adult populations; and b) whether the paradox varies by race or stratified age. As previously stated, different patterns in the association between BMI and mortality have been observed between African American and White adults, such that the association is weaker for African Americans than it is for Whites.[32] These findings may suggest that parity in BMI may not translate to similar body composition or comparable risk to health outcomes. Addressing these questions may advance our understanding of key contributors to late life health disparities and inform the development of targeted prevention strategies aimed at obesity and obesity-related health conditions. Therefore, the aim of this study was to examine the relationship between weight classification, cognitive function and physical function, and to determine whether these associations were modified by race or stratified age in a sample of community-dwelling older adults.

Methods

Data Source and Participants

The Collaborative Assessment to Revitalize the Elderly (CARE) program was a health improvement program designed to screen for risk factors for frailty and implement an evidence-based intervention to increase physical function in community-dwelling elders at senior residential sites and community centers in Saint Louis, Missouri. Overall inclusion criteria for participation in the CARE program were: aged >55 years, community-dwelling, and the ability to give informed consent. For the purposes of this study, age was stratified (young-old, aged 55-74 years; older, aged ≥75 years) and baseline data were analyzed. We stratified age because previous reports have shown distinct associations between BMI quartiles and cognitive outcomes when comparing young-old and older adults.[18]

Instruments

Anthropometric Measure

Height and weight were obtained using standardized examination procedures and calibrated equipment, and BMI was computed as the ratio of weight-to-height squared (kg/m^2). World Health Organization (WHO) BMI classification was used to categorize participants as underweight, normal weight, overweight, or obese. Underweight participants were excluded due to their small sample size (n=2).

Physical Function

The mini-Physical Performance Test (mini-PPT)[33] was used to measure balance, strength and mobility. This 4-item, validated measure includes 4 components: picking up a penny from the floor, a timed 50-ft walk, chair rises (5 times), and a progressive Romberg test. Higher scores indicated better performance. Handgrip strength was used to measure forearm strength. This performance-based measure is correlated with general muscle strength[34] and activities of daily living abilities.[35] Participants squeezed the dynamometer with their dominant hand; their performance was measured in pounds. Higher scores indicated greater strength.

Cognitive Function

The Short Blessed Test (SBT) was used to assess general cognition. This cognitive screening measure tests orientation and memory and is designed to discriminate between mild, moderate, and severe cognitive impairment.[36] For the SBT, higher scores indicate poorer performance. Trail-making tests (TMT) measured psychomotor speed and complex attention. Trail-making Test-B (TMT-B) also assesses cognitive flexibility, a key component of executive function.[37] For this test, participants drew lines to connect alphanumeric stimuli in ascending order that were randomly placed on a page (TMT-A). In the more difficult condition (TMT-B), participants alternately tracked two sets of stimuli (letters, numbers) while performing the task. Scores reflect time taken to complete the tasks; higher scores reflect poorer performance. In addition to assessing TMT-A and TMT-B performance, a difference score (TMT-B minus TMT-A) was also calculated to reflect the unique task requirements of TMT-B.[38]

Covariates

As potential predictors of the outcome, covariates were selected based on relevant literature then confirmed based on significant relations with outcome variables. Potential covariates included self-reported general health perception, smoking status, number of medications and depression. General health perception was rated (1=poor to 5=excel-

Table 1. Demographic characteristics of study sample

Variables	Total	White			African American			P
		Normal	Overweight	Obese	Normal	Overweight	Obese	
N	331	44	51	39	32	56	109	
Age	76.9 ± 9.4	84.4 ± 7.8	82.6 ± 6.9	78.3 ± 8.7	77.3 ± 9.0	75.3 ± 8.5	72.1 ± 8.7	<.001
Hispanic, n (%)	6 (1.7)	0 (0)	1 (2.0)	0 (0)	3 (9.4)	1 (0.4)	1 (0.1)	X^2=.40
Female, n (%)	313 (94.6)	44 (100)	46 (90.2)	35 (89.7)	27 (84.4)	48 (85.7)	99 (90.8)	X^2=.19
Smoking, n (%)	29 (8.8)	0 (0)	1 (2.0)	1 (2.6)	6 (18.8)	9 (14.3)	12 (11)	X^2<.001
BMI, kg/m^2	30.5 ± 7.2	22.3 ± 1.5	27.7 ± 1.3	35.8 ± 4.5	22.7 ± 1.6	28.0 ± 1.2	37.3 ± 6.1	X^2<.001
Medications	7.2 ± 4.1	7.4 ± 4.4	7.6 ± 3.2	10.1 ± 5.9	7.0 ± 4.2	5.6 ± 2.9	6.9 ± 3.6	<.001
GHP	2.8 ± .8	3.0 ± .7	2.9 ± .8	2.8 ± .8	2.7 ± .8	2.8 ± .8	2.6 ± .7	.03
BPP	3.6 ± 1.4	3.7 ± 1.2	3.9 ± 1.4	3.9 ± 1.3	4.1 ± 1.4	3.9 ± 1.3	3.4 ± 1.3	.76
PHQ-9	3.8 ± 4.0	3.3 ± 3.3	3.2 ± 3.4	3.8 ± 4.4	2.8 ± 3.4	3.8 ± 4.4	3.9 ± 4.1	.70
Mini-PPT	8.9 ± 3.3	8.9 ± 2.8	8.5 ± 2.9	9.2 ± 3.2	9.6 ± 3.5	9.2 ± 3.2	9.0 ± 3.7	.06
TMT-A	69.1 ± 40.6	66.2 ± 41.7	57.6 ± 31.0	82.2 ± 48.3	87.7 ± 45.0	82.2 ± 48.3	70.1 ± 38.1	<.001
TMT-B	146.2 ± 40.1	149.9 ± 32.4	136.7 ± 43.0	152.7 ± 41.0	165.5 ± 24.1	152.7 ± 41.0	150.2 ± 38.8	<.01
SBT	1.6 ± 2.1	2.2 ± 2.3	1.2 ± 1.5	1.7 ± 2.7	1.9 ± 2.1	1.7 ± 2.7	1.5 ± 1.9	.55

Data are means ± SD unless noted otherwise.
P, statistically significant difference by race.
BMI, body mass index; smoking categorized as current smoker vs previous smoker/never smoked; medications, number of medications; PHQ-9, patient health questionnaire 9-item; GHP, general health perception; BPP, bodily pain perception; Mini-PPT, mini Physical Performance Test; TMT-A, Trail-making Test A; TMT-B, Trail-making Test Part B; SBT, Short Blessed Test

lent), and smoking status was dichotomized as current smoker vs previous smoker/never smoked. The 9-item Patient Health Questionnaire (PHQ-9) was used to determine severity of depression symptoms.

Statistical Analysis

Descriptive statistics were computed for all predictor variables (race, age, BMI category), outcome variables (physical function and cognitive function scores), and prospective covariates. TMT-A, SBT, and PHQ-9 performance were square root transformed to correct positive skewness. Separate hierarchical multiple regression models were employed to determine associations between race (African American vs White), BMI, and stratified age (young-old: aged 55-74 years; old, aged >75 years) on each outcome, while adjusting for covariates. Body mass index was coded with binary values and the obese group served as the referent group. Only covariates that correlated with outcome variables and did not demonstrate multicolinearity were included. Interaction terms were created to assess the combined effect of primary predictors on functional outcomes. Relevant covariates where entered in to the model first, followed by primary predictors, and interaction terms.

Results

Demographic characteristics are summarized in Table 1. Of the 331 participants in the sample, most were women (94.6%), and the average age was 77. White elders were significantly older (P<.001) and reported better general health (P=.03) than African American elders. On average, the sample was obese and African Americans had a higher prevalence of overweight and obesity (P<.001).

Table 2 illustrates results from the hierarchical regression analysis for physical function outcomes and general cognition measure (SBT). Depression scores, number of medications, and general health perception were included as covariates for mini-PPT and grip strength outcomes (Model 1, data not shown). For both models, stratified age was a significant predictor (Model 3: mini-PPT [B=-2.03, P<.001]; grip strength [B=-2.03, P<.001]), indicating that young-old adults performed better than older adults on these measures. Race and BMI classifications were not significant predictors; nor were there significant interactions for this model (Ps>.05). For general cognition (SBT), number of medications and depression scores were included as covariates (Model 1, data not shown). There was a trend for stratified age (B=.31, P=.05) and race (B=-.40, P=.05), but not for BMI classifi-

Table 2. Hierarchical multiple regression analysis to predict physical function and general cognition, Short Blessed Test

	Mini-PPT				Grip Strength				SBT			
	Model 2		Model 3		Model 2		Model 3		Model 2		Model 3	
	B	SE	B	SE	B	SE	B	SE	B	SE	B	SE
Age	-2.43[a]	.40	-2.03[b]	.48	-2.43[a]	.40	-2.03[b]	.48	.29[a]	.13	.31	.15
Race	.17	.40	.03	.63	.17	.40	.03	.63	-.25	.13	-.40	.21
Normal weight	.93	.45	2.66	2.01	.93[a]	.46	2.66	2.01	.38[a]	.15	-.18	.66
Overweight	.30	.40	1.25	1.53	.30	.40	1.25	1.53	.03	.14	-.25	.53
Normal weight x race			.15	1.01			.15	1.01			.52	.33
Normal weight x age			-1.14	1.15			-1.14	1.15			-.10	.36
Overweight x race			.56	.88			.56	.88			.15	.30
Overweight x age			-.73	.57			-.73	.57			.02	.20

a. P<0.05.
b. P<.001.
Referent was obese group.
Model 1 mini-PPT and grip strength covariates were depression scores, number of medications, general health perception; model 1 SBT covariates were depression scores and number of medications.
Mini-PPT, mini physical performance test; SBT, Short Blessed Test.
Mini-PPT- Model 1: $F_{(3,296)}=11.94$, $P<.001$, $R^2=.10$, $R^2\Delta=.10$; Model 2: $F_{(4,292)}=10.50$, $P<.001$; $R^2=.22$, $R^2\Delta=.11$; Model 3:$F_{(4, 288)}$) =.61 $P=.65$, $R^2=.22$, $R^2\Delta=.007$.
Grip Strength-Model 1: $F_{(3,257)}=3.53$; $P=.01$; $R^2=.04$; $R^2\Delta=.04$; Model 2: $F_{(4, 253)}=20.01$, $P<.001$; $R^2=.27$; $R^2\Delta=.25$; Model 3:$F_{(4,249)=}1.79$, $P=.13$, $R^2=.29$, $R^2\Delta=.02$.
SBT-Model 1: $F_{(2,249)}= .70$, $P=.48$, $R^2=.006$; $R^2\Delta=.006$; Model 2: $F_{(4,245)}= 3.65$, $P=.007$; $R^2=.06$, $R^2\Delta=.05$; Model 3: $F_{(4,241)}= .63$, $P=.63$, $R^2=.07$, $R^2\Delta=.01$.

cation or interaction terms (Ps>.05).

Table 3 illustrates the results from the hierarchical regression analysis for TMT performance. Number of medications and depression scores were included in the first block as covariates (data not shown). For psychomotor speed (TMT-A) performance, stratified age (B=1.39, P<.001) and race (B=-1.86, *P*<.001) were significant predictors of psychomotor speed; indicating young-old and White participants performed better on TMT-A than older adults and African American participants. No significant interactions were observed (Ps>.05). For cognitive flexibility (TMT-B) performance, similar results were

Table 3. Hierarchical multiple regression analysis to predict cognitive performance, Trail-making Test

	TMT-A				TMT-B				TMT difference			
	Model 2		Model 3		Model 2		Model 3		Model 2		Model 3	
	B	SE	B	SE	B	SE	B	SE	B	SE	B	SE
Age	1.29[c]	.29	1.39[c]	.35	21.72[c]	6.09	24.11[b]	7.40	6.49	5.81	8.80	7.12
Race	-1.69[c]	.30	-1.86[c]	.49	-26.94[c]	6.20	-33.34[c]	9.41	-6.44	5.98	-10.17	9.33
Normal weight	0.80*	.36	1.54	1.51	16.03[a]	7.23	29.90	28.92	.78	7.04	-6.96	28.02
Overweight	0.51	.31	.09	1.16	4.00	6.34	-15.34	22.84	-7.12	6.12	-2.16	22.06
Normal weight x race			.64	.79			17.97	16.26			13.92	15.84
Normal weight x age			-.96	.83			-23.36	17.02			-7.98	16.33
Overweight x race			.03	.69			7.10	13.66			2.53	13.30
Overweight x age			.16	.43			3.90	8.62			-3.34	8.26

a. P<.05.
b. P<.01.
c. P<.001.
Referent was obese group.
Model 1 covariates were depression scores and number of medications.
TMT, Trail-making Test.
TMT-A- Model 1: $F_{(2,243)}=.95$, $P=.38$, $R^2=.008$, $R^2\Delta=.008$; Model 2: $F_{(4,239)}=10.08$, $P<.001$; $R^2=.008$, $R^2\Delta=.008$; Model 3:$F_{(4, 235)}=.46$, $P=.76$, $R^2=.15$, $R^2\Delta=.007$.
TMT-B-Model 1: $F_{(2,223)}=.23$; $P=.78$; $R^2=.002$; $R^2\Delta=.002$; Model 2: F(4,219)=6.59, $P<.001$; $R^2=.10$; $R^2\Delta=.10$; Model 3:$F_{(4,215)}=.75$, $P=.55$, $R^2=.10$, $R^2\Delta=.10$.
TMT difference-Model 1: $F_{(2,218)}= .80$, $P=.45$, $R^2=.001$; $R^2\Delta=.001$; Model 2: $F_{(4,214)}= .93$, $P=.44$; $R^2=.18$ $R^2\Delta=.01$; Model 3: $F_{(4,210)}= .24$, $P=.91$, $R^2=.02$, $R^2\Delta=.005$.

observed for stratified age (B=21.72, P<.001) and race (B=-26.94, P<.01). Obese weight status compared with normal weight (B=16.03, P=.02) was associated with better cognitive flexibility. There was no significant difference in cognitive flexibility between normal weight and obese, or obese and overweight participants, nor were there any significant interactions (Ps>.05). Trail-making test difference scores revealed no significant main effects or interactions (Ps>.05).

Discussion

In this sample of community-dwelling older adults, BMI was significantly associated with cognitive flexibility. Older adults who were obese had significantly better cognitive flexibility performance than normal weight older adults, and this association was not influenced by age or race. In addition, excess adiposity was not associated with better general cognition or physical function in our sample.

The obesity paradox remains controversial despite mounting evidence of its existence. Questions remain regarding under what conditions the obesity paradox exists and what underlying processes contribute to this phenomenon. Our findings add to this discussion by demonstrating an association between obesity status and cognitive function. Our results support those found by Fitzpatrick and colleagues.[39] In their study, late-life obesity was associated with a reduced risk for dementia, relative to late-life normal weight.[39] Although dementia was not our outcome of interest, we did find obesity to be associated with better executive function. Prior research has primarily focused on the association between adiposity and dementia risk,[18,40,41] while fewer studies have examined how adiposity relates to specific cognitive domains.[13,19] We did not find a significant association between excess adiposity and processing speed. Our null results were inconsistent with previous studies showing a positive association between adiposity and processing speed,[13] this may be due to our cursory cognitive battery as studies yielding positive results administered more robust cognitive measures. With regard to general cognition, our null findings are aligned with previous research.[42] Our study adds to this literature by documenting an association between excess adiposity and cognitive flexibility. A focus on specific cognitive domains is important because age-related and disease-related changes in cognitive processes are typically not uniform;[43] therefore, a better understanding of which cognitive domains are most affected by adiposity and adiposity-related health conditions could inform strategies for diagnosis and treatment of cognitive conditions in older adults. Future research is needed to better delineate the association between late-life excess adiposity and cognitive function.

Older adults who were obese had significantly better cognitive flexibility performance than normal weight older adults…

In our study, BMI was not associated with physical function measures. These findings are inconsistent with previous reports showing paradoxical associations between adiposity and physical function,[5] and with studies reporting higher BMI to be associated with worse physical function.[44] One reason why our results may differ from that of previous reports is our use of a single measure to assess primarily lower body physical performance. The mini-PPT,[33] although validated, tested previously in community settings, and derived from a more extensive physical performance test, has not been compared with other performance measures and therefore may not be comparable to other objective measures of physical function. In addition, our findings may provide support for the argument that BMI is a less than optimal indicator of adiposity and health risk in aged populations, and indices of central adiposity are more robust indicators of health status and predictive of health-related outcomes.[45]

Our study was limited by a cross-sectional design and precludes us from determining causality. We did not collect data on vascular comorbidities, which are known to contribute to cognitive[46] and physical function[47] in aged populations; therefore we could not account for the contribution of these factors to our findings. Males were also underrepresented in our study sample. Several researchers have argued that BMI classification may not be the most robust proxy of excess body fat in older adults and other anthropometric measures such as waist-to-hip ratio and other measures of central obesity may be more appropriate.[29] However, consensus regarding the best measure of obesity in older adults is lacking.[48] Also, our use of a limited physical function and cognitive battery hinders the generalizability of our results. Finally, we did not query the educational background of our sample and therefore could not account for any significant educational differences between African Americans and Whites in our sample.

Conclusion

Despite these limitations, our study has several strengths. Our study advances existing knowledge on the obesity paradox in diverse, community-dwelling older adult populations. Few studies have explored whether the obesity paradox persists in non-patient populations,[20] and even fewer studies have investigated this phenomenon in racially diverse populations.[25] For this reason, our study makes a noteworthy contribution to research focused on key contributors to functional health outcomes in aged populations. Future studies with larger sample sizes are needed to replicate our findings. Future work should also include neuroimaging and biomarkers of adipose tissue to examine the underlying biological processes linking late-life adiposity to executive function.

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Conflict of Interest

No conflicts of interest to report.

Author Contributions

Research concept and design: Skinner, Wilkins; Acquisition of data: Wilkins; Data analysis and interpretation: Skinner, Abel, McCoy, Wilkins; Manuscript draft: Skinner, Abel, McCoy, Wilkins; Statistical expertise: Skinner; Acquisition of funding: Wilkins; Administrative: Skinner, Abel, McCoy, Wilkins; Supervision: Wilkins

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