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Associations of decision making abilities with blood pressure values in older adults

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Abstract

Objectives—Decision making, key to successful aging, has implications for financial success, physical health, and well-being. Decision making also has implications for age-related cognitive decline and dementia. While poor decision making has been linked with increased risk of mortality, less is known regarding its associations with chronic disease indicators. We investigated the associations of decision making with blood pressure values (i.e., systolic blood pressure, systolic BP, mean arterial pressure, MAP, and pulse pressure, PP, separately) in a community-based cohort study of aging.

Methods—Participants were 908 non-demented older adults (age ~81 years;75% women) from the Rush Memory and Aging Project. Decision making was measured using questions designed to simulate materials used in financial and healthcare settings in the real world and yielded a total score and domain-specific health and financial decision making scores. Two seated and one standing BP measurement were taken with all three contributing to average systolic BP, MAP i.e., [systolic BP + (2*diastolic BP)]/3, and PP, i.e., systolic - diastolic BP. Participants were queried about hypertension status and anti-hypertension medications were visually inspected and coded. Participants also underwent medical history and cognitive assessments.

Results—In separate multivariable linear regression models, total decision making scores were inversely associated with systolic BP, MAP, and PP after adjusting for age, sex, education, anti-hypertension medication use, diabetes, and cumulative cardiovascular disease burden (p-values=0.03). Decision making remained associated with these BP values after additional adjustment for global cognition.

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Conclusions—Poorer decision making is associated with higher BP values in non-demented older adults.

Keywords

decision making; blood pressure; mean arterial pressure; pulse pressure; aging

Introduction

Decision making, particularly in health and financial realms, is key to successful aging. Advantageous decisions have far reaching implications including financial success, physical health, and well-being, while poor decision making skills can lead to financial losses, health risks, and long-terpm stressors [1–3]. We and others have reported that poor decision making abilities are associated with alterations in cognition and dementia [4–6]. Additionally, poor decision making skills have also been linked with incident adverse cognitive outcomes [7] and increased risk of mortality [8]. Less is known regarding the associations between decision making and chronic disease indicators, e.g., cardiovascular risk factor burden, that have been linked with other decision making related abilities [9] as well as cognitive decline, dementia [10], and death [11].

A main driver of cardiovascular risk factor burden is elevated blood pressure, as evidenced by the fact that in the United States alone, the prevalence of hypertension (as defined as systolic blood pressure greater than or equal to 140 mm/Hg, or diastolic blood pressure greater than or equal to 90 mm/Hg, or current medication use to lower high blood pressure) in adults 60 years of age and older is over 60% [12]. Furthermore, according to the World Health Organization (WHO), the risk of cardiovascular disease doubles for each increment of 20/10 mmHg of blood pressure, starting as low as 11/75 mm/Hg in some age groups [13]. Thus, this study examines the associations between decision making and objectively measured blood pressure values of systolic blood pressure (systolic BP), mean arterial pressure (MAP), and pulse pressure (PP) in a community-based cohort of older adults with and without hypertension. We included MAP and PP as additional blood pressure values given they considers both systolic and diastolic blood pressure, and have been related to other blood pressure indicators including cerebral blood flow [14, 15]. We hypothesize that poorer decision making is associated with higher levels of systolic BP and MAP after controlling for age and other relevant confounders. Furthermore, despite evidence that even subtle age-related changes in cognition have detrimental effects on decision making [4, 16], we hypothesize that the associations between decision making and blood pressure values will withstand additional adjustments for global cognitive functioning.

Methods

Participants

Individuals included in this research were participants from the Rush Memory and Aging Project (1997-present), an ongoing longitudinal clinical-pathologic cohort study of aging [17–19]. The Institutional Review Board of Rush University Medical Center approved the study and participants gave written informed consent in accordance with the Declaration of

Helsinki. Participants were enrolled without known dementia and underwent annual clinical evaluations.

The Rush Memory and Aging Project started in 1997 and a decision making sub-study was introduced in 2010 [20]. Of the 1,939 participants enrolled, 1,146 participants were alive and active in the Rush Memory and Aging Project and of those, 1,056 had available decision making data. We excluded 62 participants who had dementia at the time of their decision making sub-study assessment. Dementia was diagnosed by experienced clinicians based on a uniform structured clinical evaluation [18] and per the criteria of the National Institute of Neurologic and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association [21]. Of the remaining 994 non-demented participants, 908 (91%) participants also had complete data on blood pressure values that coincided with their study visit and were included in these analyses.

Assessment of Decision Making

Described in detail elsewhere [20], our assessment of health and financial decision making consisted of a 12-item questionnaire [4, 8, 16, 22]. Participants are presented with a healthcare module that includes 6 questions of increasing complexity about HMO plans and a financial module that includes 6 questions of increasing complexity about mutual funds. This tool was specifically designed to simulate materials used in financial and healthcare settings in the real world. Participants were provided with preferences and questions measured decisions that reflect understanding of information presented. Complexity was increased by increasing the number of options provided. For example, one of the simple problems involves information on three mutual funds, including the gross annual return, account management fee, minimum investment, and years of activity, and asks respondents to select the fund with the smallest account management fee. A complex problem presents similar information but about seven mutual funds and asks participants to select the most appropriate fund given pre-specified preferences. The total score is the sum of items answered correctly (range = 0–12) with sub-scale scores for health and financial decision making ranging from 0 to 6. This measure has been shown to have adequate psychometric properties including high inter-rater reliability and short-term temporal stability [16].

Blood Pressure Assessment and Value Determinations

As previously described [23], blood pressure (BP) was measured in the right arm with a mercury sphygmomanometer by trained research assistants. Two seated BP readings were taken at 30 second intervals following a 5-minute rest period; 1 minute after being requested to stand, a third, standing BP was taken. Systolic and diastolic BP was calculated separately by averaging all three readings. In addition to systolic BP, our additional BP indices was mean arterial pressure and pulse pressure.

MAP is an index of the steady component or average of pressure in the arteries during a single cardiac cycle. While it can only be measured directly by invasive monitoring, it can be approximated using the following formula: [systolic BP + (2*diastolic BP)]/3. MAP was of particular interest because it is considered a critical hemodynamic factor that is a better marker of perfusion to vital organs than systolic BP [24]. For example, elevations in MAP above the normal range cut-point of 100–110 mmHg will, over time, contribute to increased oxygen demand and hence, arterial pressure, subsequent vascular injury and end organ damage including stroke [25]. Alternatively, MAP that falls below the normal range cut-point of 60–65 mmHg for a considerable time period has the potential to cause vital organ ischemia and shock.

PP is an index of the discrepancy between the maximum pressure applied during a heartbeat (i.e., systolic BP) and the pressure in the arteries between heartbeats (i.e., diastolic BP). Thus, PP is the difference between systolic and diastolic blood pressure, i.e., systolic BP minus diastolic BP. PP, thought to represent arterial stiffness, increases with increasing age [26], and has been associated with cognitive impairment [27] for meta-analytic review). Furthermore, older adults often experience PP above the normal range of 40–60 mm/Hg, and such age-related elevations have often been associated with increased risk of heart attack or stroke. In contrast, PP less than 40 mm/Hg may indicate decreased cardiac output and is often observed in individuals with heart failure.

Covariates

In addition to age, sex and years of education, we adjusted for the variables outlined below. Given that greater than 90% of participants are insured through Medicare, we did not adjust for insurance status in analyses.

Anti-hypertension medication use—Participants supplied all medications prescribed by a doctor, vitamins, supplements, and over-the-counter remedies/medicines taken in the 2 weeks prior to the study visit. Visual inspection of all containers allowed for medication documentation. Medications were coded using the Medi-Span Drug Data Base system [28] including prescription medications for hypertension. An individual was deemed positive for anti-hypertension medication use if they possessed prescription medication for hypertension. We chose to adjust for this factor given that adherence to anti-hypertensive medications and subsequent BP presumed to follow may dampen the associations between decision making and blood pressure values in individuals with hypertension.

Diabetes status—Participants were queried about diabetes status and supplied all medications prescribed by a doctor and taken in the 2 weeks prior to the study visit; they also provided a blood specimen using standard procedures that was analyzed by Quest Diagnostics. Using the criteria set forth by the America Diabetes Association [29], diabetes was defined by at least one of the following glycemic values: glucose of >126 mg/dL or hemoglobin A1C >6.5%. Diabetes was also defined based on participant's self-report of taking medication for diabetes including prescription medications for diabetes (insulin and non-insulin related) that was verified by medication review and coding using the Medi-Span Drug Data Base system [28] at the study visit. Diabetes is often co-morbid with hypertension [30] and has been associated with cognitive impairment in MAP participants [31] as well as other studies ([32] for review). Thus, we adjusted for this factor in all analyses.

Cumulative vascular disease burden—Vascular disease burden, a known contributor to cognitive impairment (e.g., [33, 34]) was derived using self-report questions probing the presence or absence of claudication symptoms, stroke, heart conditions, or congestive heart failure. In addition to self-report, evaluation of the presence or absence of stroke was also based on neurological exam and interview from which the physician would render a diagnosis of stroke. As previously described [35], each item was given a value of 0 or 1 with the cumulative vascular burden score ranging from 0 to 4.

Global Cognitive Functioning—All participants underwent an annual cognitive evaluation detailed elsewhere [17–19]. Briefly, cognitive tests were administered in an identical fashion at annual evaluations. A global composite score was created by converting raw scores on the 19 cognitive tests to standard (z) scores using the mean and standard deviation from the baseline evaluation. A person's standard scores across all tests were then averaged to yield a single composite score summarizing level of global cognitive function. Evidence suggests that even subtle age-related changes in cognition have detrimental effects on decision making [4, 16], thus, we added our metric of global cognition as an additional covariate in fully-adjusted models as outlined below.

Statistical Analyses

We tested bivariate associations between key participant characteristics and blood pressure values, i.e., systolic blood pressure, mean arterial pressure or MAP, and pulse pressure or PP, using correlations or independent sample t-tests as appropriate. We used linear regression models to examine the associations of decision making – separately for the total, health, and financial decision making scores – with blood pressure values (separately for systolic blood pressure, MAP, and PP). In these models, each blood pressure value was the continuous outcome. All models included terms for age, sex, and education (core model). Sequential models were then implemented first adding anti-hypertension medication use (i.e., medication use verified at study visit), diabetes status (presence/absence), and cumulative vascular disease burden (Model 1), then further adjusting for global cognitive functioning (fully-adjusted Model 2). All analyses were programed using SAS/STAT software, Version 9.4 of the SAS System for Linux (SAS Institute, Cary, NC) and significance was set using $p<0.05$.

Results

Participants were approximately 80 years of age with approximately 15 years of education; 75% of participants were female. The mean total decision making score was 7.8 out of 12. Average BP was 133/77 mmHg, average MAP and PP were 96 and 56 mmHg, respectively. Approximately 70% of our sample was taking medication for hypertension, and 20% met criteria for diabetes. Other covariates are described in Table 1.

Bivariate correlations between key participant characteristics and blood pressure values (Table 2) revealed that age correlated with positively with systolic BP and PP, and negatively with MAP (p-values≤0.03), but education only correlated with systolic BP and PP (negatively) ($p\leq0.01$). Cumulative vascular disease burden correlated with PP only ($p=0.007$). Independent sample t-tests indicated that systolic BP and PP did not differ by sex, but women (96.5±13.1 mmHg) had higher MAP than men (93.9±11.9 mg/dL; p=0.008). All three decision making measures were negatively correlated with all three blood pressure values (p-values≤0.04). Global cognition negatively correlated with systolic BP and PP only (p=0.01).

Association of Decision Making with Blood Pressure Values

Total Score—We first examined the association of the total decision making score with systolic BP, MAP, and PP (separately). In the core regression model adjusted for age, sex, and education, there was an inverse association of total decision making with systolic BP (estimate = −0.76, SE = 0.26, p=0.004) as well as MAP (estimate = −0.48, SE = 0.17, p=0.006), separately. These association remained after additional adjustments for anti-hypertension medication use, diabetes status, cumulative vascular disease burden (Model 1: systolic BP estimate = −0.76, SE = 0.26, p=0.003; MAP estimate = −0.50, SE = 0.17, p=0.005), as well as global cognitive functioning (both p-values=0.03). Likewise, in the core regression model adjusted for age, sex, and education, there was an association of lower total decision making scores with higher PP (estimate = −0.41, SE = 0.18, p=0.02) that remained after additional adjustments for anti-hypertension medication use, diabetes status, cumulative vascular disease burden (Model 1: estimate = −0.39, SE = 0.18, p=0.03). It was modestly attenuated following additional adjustment for global cognitive functioning (p=0.09). Specific estimates for fully-adjusted Model 2 are outlined in Table 3.

Health and Financial Sub-scores—Next, we examined the associations of the health and financial decision making sub-scores, separately, with blood pressure values to determine if there was a particular domain-specific aspect of decision making that accounted for the results outlined above. In the core regression model adjusted for age, sex, and education, there was an inverse association of health decision making with systolic BP (estimate = −1.14, SE = 0.44, p=0.009) and MAP (estimate = −0.71, SE = 0.30, p=0.01), separately. The association of lower health decision making scores and higher systolic BP remained significant after adjustments for anti-hypertension medication use, diabetes status, and cumulative vascular disease burden (Model 1: estimate = −1.15, SE = 0.44, p=0.009). The same was true for the association of lower decision making scores and higher MAP (Model 1: estimate = −0.74, SE = 0.30, p=0.01). These associations were modestly attenuated following additional adjustment for global cognitive functioning (fully-adjusted Model 2: systolic BP estimate = −0.94, SE = 0.50, p=0.055; MAP estimate = −0.60, SE = 0.33, p=0.07). There was an inverse association of lower health decision making scores with higher PP in the core model adjusted for age, sex, and education, estimate = −0.64, SE = 0.30, p=0.03, that remained significant after adjustments for anti-hypertension medication use, diabetes status, and cumulative vascular disease burden (Model 1: estimate = −0.62, SE = 0.30, p=0.04). The association between health decision making and PP did not reach significance in fully adjusted Model 2 (estimate = −0.52, SE = 0.34, p=0.12).

There was an association of lower financial decision making scores with higher systolic BP after adjusting for age, sex, and education (estimate = −1.22, SE = 0.50, p=0.01) that remained after Model 1 adjustments for anti-hypertension medication use, diabetes status, and cumulative vascular disease burden (estimate = −1.22, SE = 0.50, p=0.01); it was modestly attenuated following additional adjustment for global cognitive functioning (estimate = −0.97, SE = 0.54, p=0.07). The association of financial decision making with MAP followed a similar pattern of significance in initial age, sex, and education adjusted (estimate = −0.80, SE = 0.33, p=0.01) and additionally adjusted Model 1 (estimate = −0.82, SE = 0.33, p=0.01); results were modestly attenuated following additional adjustment for global cognitive functioning in Model 2 (estimate = −0.65, SE = 0.36, p=0.07). In contrast, financial decision making was not associated with PP, regardless of adjustments (core Model: estimate = −0.62, SE 0.34, p=0.07; Model 1: estimate = −0.67, SE = 0.34, p=0.07; Model 2: estimate = −0.47, SE 0.37, p=0.20).

Interaction Between Decision Making and Hypertension on Blood Pressure Values

Given that our sample consisted of participants with and without hypertension, we investigated whether hypertension status modified our aforementioned results. Thus, we added the interaction term of decision making and hypertension to fully-adjusted models outlined above. There were no significant interactions of decision making (total, health, or financial, separately) and hypertension with either systolic BP (p-values≥0.77), MAP (p-values≥0.55), or PP (p-values≥0.45).

Discussion

We investigated the association of decision making with blood pressure values in a community-based study of more than 900 non-demented older adults with and without hypertension. Poorer decision making was associated with elevations in systolic BP, MAP, and PP, respectively. Furthermore, these relationships were not modified by hypertension status. Thus, results suggest an important link between decision making and blood pressure values in old age, even among individuals who are not being monitored and/or treated for hypertension-related issues.

These results build upon the literature on decision making and adverse health outcomes in several ways. First, while poorer decision making has been linked to increased risk of mortality [8], to our knowledge, this is the first study that suggests a possible chronic health-related driver of this association, i.e., elevations in blood pressure values. Second, although abilities that are critical for decision making including health literacy [2] have been associated with elevations in blood pressure [36], our results extends this work to examine decision making directly. Taken together, our results suggest that poorer decision making not only has negative implications for end of life [8], it is also associated with other adverse health outcomes of a more chronic nature.

In addition to the total score on our measure of decision making being associated with blood pressure values, domain-specific health and financial decision making were significantly associated with systolic BP, MAP, and PP. Domain specific health decision making scores were associated with all three blood pressure values with systolic BP and MAP results modestly attenuated following final adjustment for global cognition; PP results were no longer significant in the fully adjusted model. Like results using the health decision making score, systolic BP and MAP results for domain-specific financial decision making were modestly attenuated following final adjustment for global cognition; financial decision making was not associated with PP, regardless of adjustment. While for the health and financial decision making analyses involving systolic BP and MAP, the fully-adjusted models were short of significance, the results were not materially different suggesting that the restricted range of scores on the domain-specific indices limited our power to detect a robust signal in their associations with these two blood pressure values.

While the basis of the association between decision making and blood pressure values in older adults is unknown, the cross-sectional nature of our data demands that we consider both directions of our resulting associations. For example, poorer decision making may lead to negative health behaviors across the lifespan which may lead to more adverse health status in older age. Thus, older persons who historically made poor decisions may have engaged in behaviors associated with elevations in blood pressure values including smoking, sedentary behavior, and/or poorer eating habits, chosen not to seek medical attention for signs of elevated blood pressure, and/or decided not to fill or adhere to anti-hypertension prescriptions from their doctor. Alternatively, it is also equally feasible that chronic elevations in blood pressure values including systolic BP, MAP, and PP may have promoted alterations to end organs including brain [25] in the form of white matter hyperintensities [37] and/or micro-infarcts [38] that contributed to impairments in complex thinking and behavioral processes that underlie decision making. Thus, blood pressure values could affect decision making as an earlier marker of cognitive decline. Future longitudinal studies of decision making and these blood pressure values as well as incident hypertension are needed to examine temporal associations and the underlying mechanisms linking them.

This study has a number of strengths including a well-validated measure of health and financial decision making. Likewise, by incorporating systolic BP, MAP, and PP, all of which have been associated with numerous other cardiovascular-related indices [14, 39], our results suggest that decision making is related to multiple blood pressure values in older adults. Additionally, we adjusted for multiple potential confounders including other chronic cardiovascular diseases including diabetes, and anti-hypertension medication use. Limitations of this study included the cross-sectional nature of the analyses. Additionally, 70% of participants were found to have hypertension as diagnosed using the latest American Heart Association criteria. While this is consistent with the fact that older adults have the greatest prevalence of hypertension [12, 40], the high prevalence in our sample meant we were unable to perform sensitivity analyses with and without participants with hypertension. It should be noted, however, that controlling for anti-hypertension medication – one criteria by which to diagnose hypertension – did not affect our results. Our participants were primarily non-Latino white and highly educated, thus, our results may lack generalizability; however, we are actively collecting similar decision making data in non-Latino blacks. Even with these limitations, our findings associating decision making with systolic BP, MAP, and PP, separately, provide support for promoting decision making capacity in older adults across the spectrum of health and disease and suggest that better decision making may help facilitate regulation of blood pressure values.

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References

[1]. Denburg NL, Recknor EC, Bechara A, Tranel D (2006) Psychophysiological anticipation of positive outcomes promotes advantageous decision-making in normal older persons. Int J Psychophysiol 61, 19–25. [PubMed: 16426691]

[2]. James BD, Boyle PA, Bennett JS, Bennett DA (2012) The impact of health and financial literacy on decision making in community-based older adults. Gerontology 58, 531–539. [PubMed: 22739454]

[3]. Li Y, Baldassi M, Johnson EJ, Weber EU (2013) Complementary cognitive capabilities, economic decision making, and aging. Psychol Aging 28, 595–613. [PubMed: 24040999]

[4]. Boyle PA, Yu L, Wilson RS, Gamble K, Buchman AS, Bennett DA (2012) Poor decision making is a consequence of cognitive decline among older persons without Alzheimer's disease or mild cognitive impairment. PLoS One 7, e43647. [PubMed: 22916287]

[5]. Gamble K, Boyle P, Yu L, Bennett D (2015) Aging and Financial Decision Making. Manage Sci 61, 2603–2610. [PubMed: 26622068]

[6]. Han SD, Boyle PA, James BD, Yu L, Bennett DA (2015) Mild cognitive impairment is associated with poorer decision-making in community-based older persons. J Am Geriatr Soc 63, 676–683. [PubMed: 25850350]

[7]. Stewart CC, Yu L, Wilson RS, Bennett DA, Boyle PA (2019) Healthcare and Financial Decision Making and Incident Adverse Cognitive Outcomes among Older Adults. J Am Geriatr Soc.

[8]. Boyle PA, Wilson RS, Yu L, Buchman AS, Bennett DA (2013) Poor decision making is associated with an increased risk of mortality among community-dwelling older persons without dementia. Neuroepidemiology 40, 247–252. [PubMed: 23364306]

[9]. Lamar M, Wilson RS, Yu L, James BD, Stewart CC, Bennett DA, Boyle PA (2019) Associations of literacy with diabetes indicators in older adults. J Epidemiol Community Health 73, 250–255. [PubMed: 30530520]

[10]. Stefanidis KB, Askew CD, Greaves K, Summers MJ (2018) The Effect of Non-Stroke Cardiovascular Disease States on Risk for Cognitive Decline and Dementia: A Systematic and Meta-Analytic Review. Neuropsychol Rev 28, 1–15. [PubMed: 28856507]

[11]. Guo L, Zhang S (2017) Association between ideal cardiovascular health metrics and risk of cardiovascular events or mortality: A meta-analysis of prospective studies. Clin Cardiol 40, 1339–1346. [PubMed: 29278429]

[12]. Fryar CD, Ostchega Y, Hales CM, Zhang G, Kruszon-Moran D (2017) Hypertension Prevalence and Control Among Adults: United States, 2015–2016. NCHS Data Brief, 1–8.

[13]. World Health Organization, Raised blood pressure, https://www.who.int/gho/ncd/risk_factors/blood_pressure_prevalence_text/en/, Accessed 07/08.2019.

[14]. Clark LR, Nation DA, Wierenga CE, Bangen KJ, Dev SI, Shin DD, Delano-Wood L, Liu TT, Rissman RA, Bondi MW (2015) Elevated cerebrovascular resistance index is associated with cognitive dysfunction in the very-old. Alzheimers Res Ther 7, 3. [PubMed: 27391477]

[15]. Glynn RJ, Chae CU, Guralnik JM, Taylor JO, Hennekens CH (2000) Pulse pressure and mortality in older people. Arch Intern Med 160, 2765–2772. [PubMed: 11025786]

[16]. Finucane ML, Gullion CM (2010) Developing a tool for measuring the decision-making competence of older adults. Psychol Aging 25, 271–288. [PubMed: 20545413]

[17]. Bennett DA, Launer LJ (2012) Longitudinal epidemiologic clinical-pathologic studies of aging and Alzheimer's disease. Curr Alzheimer Res 9, 617–620. [PubMed: 22715984]

[18]. Bennett DA, Schneider JA, Buchman AS, Barnes LL, Boyle PA, Wilson RS (2012) Overview and findings from the rush Memory and Aging Project. Curr Alzheimer Res 9, 646–663. [PubMed: 22471867]

[19]. Bennett DA, Buchman AS, Boyle PA, Barnes LL, Wilson RS, Schneider JA (2018) Religious Orders Study and Rush Memory and Aging Project. J Alzheimers Dis 64, S161–S189. [PubMed: 29865057]

[20]. Boyle PA, Yu L, Buchman AS, Bennett DA (2012) Risk Aversion is Associated with Decision Making among Community-Based Older Persons. Frontiers in Psychology 3, 205. [PubMed: 22754545]

[21]. McKhann G, Drachman D, Folstein M, Katzman R, Price D, Stadlan EM (1984) Clinical diagnosis of Alzheimer's disease: report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. Neurology 34, 939–944. [PubMed: 6610841]

[22]. Finucane ML, Mertz CK, Slovic P, Schmidt ES (2005) Task complexity and older adults' decision-making competence. Psychol Aging 20, 71–84. [PubMed: 15769215]

[23]. Shah RC, Wilson RS, Bienias JL, Arvanitakis Z, Evans DA, Bennett DA (2006) Relation of blood pressure to risk of incident Alzheimer's disease and change in global cognitive function in older persons. Neuroepidemiology 26, 30–36. [PubMed: 16254451]

[24]. Bonsall L (2011) in Nuersing Center Blog, ed. NursingCenter L Wolters Kluwer.

[25]. Wehrwein EA, Joyner MJ (2013) Regulation of blood pressure by the arterial baroreflex and autonomic nervous system. Handb Clin Neurol 117, 89–102. [PubMed: 24095118]

[26]. Webb AJ, Rothwell PM (2014) Physiological correlates of beat-to-beat, ambulatory, and day-to-day home blood pressure variability after transient ischemic attack or minor stroke. Stroke 45, 533–538. [PubMed: 24407950]

[27]. van Sloten TT, Protogerou AD, Henry RM, Schram MT, Launer LJ, Stehouwer CD (2015) Association between arterial stiffness, cerebral small vessel disease and cognitive impairment: A systematic review and meta-analysis. Neurosci Biobehav Rev 53, 121–130. [PubMed: 25827412]

[28]. Medi-Span (1995), Indianapolis, IN.

[29]. Association AD (2010) Diagnosis and classification of diabetes mellitus. Diabetes Care 33 Suppl 1, S62–69. [PubMed: 20042775]

[30]. Long AN, Dagogo-Jack S (2011) Comorbidities of diabetes and hypertension: mechanisms and approach to target organ protection. J Clin Hypertens (Greenwich) 13, 244–251. [PubMed: 21466619]

[31]. Arvanitakis Z, Wilson RS, Li Y, Aggarwal NT, Bennett DA (2006) Diabetes and function in different cognitive systems in older individuals without dementia. Diabetes Care 29, 560–565. [PubMed: 16505506]

[32]. Arvanitakis Z, Wilson RS, Bennett DA (2006) Diabetes mellitus, dementia, and cognitive function in older persons. J Nutr Health Aging 10, 287–291. [PubMed: 16886098]

[33]. Elwood PC, Pickering J, Bayer A, Gallacher JE (2002) Vascular disease and cognitive function in older men in the Caerphilly cohort. Age Ageing 31, 43–48. [PubMed: 11850307]

[34]. Almeida OP, Tamai S (2001) Congestive heart failure and cognitive functioning amongst older adults. Arq Neuropsiquiatr 59, 324–329. [PubMed: 11460173]

[35]. Boyle PA, Buchman AS, Wilson RS, Leurgans SE, Bennett DA (2009) Association of muscle strength with the risk of Alzheimer disease and the rate of cognitive decline in community-dwelling older persons. Arch Neurol 66, 1339–1344. [PubMed: 19901164]

[36]. McNaughton CD, Kripalani S, Cawthon C, Mion LC, Wallston KA, Roumie CL (2014) Association of health literacy with elevated blood pressure: a cohort study of hospitalized patients. Med Care 52, 346–353. [PubMed: 24556896]

[37]. Liao D, Cooper L, Cai J, Toole J, Bryan N, Burke G, Shahar E, Nieto J, Mosley T, Heiss G (1997) The prevalence and severity of white matter lesions, their relationship with age, ethnicity, gender, and cardiovascular disease risk factors: the ARIC Study. Neuroepidemiology 16, 149–162. [PubMed: 9159770]

[38]. Wang LY, Larson EB, Sonnen JA, Shofer JB, McCormick W, Bowen JD, Montine TJ, Li G (2009) Blood pressure and brain injury in older adults: findings from a community-based autopsy study. J Am Geriatr Soc 57, 1975–1981. [PubMed: 19793158]

[39]. Shapiro DS, Loiacono LA (2010) Mean arterial pressure: therapeutic goals and pharmacologic support. Crit Care Clin 26, 285–293, table of contents. [PubMed: 20381720]

[40]. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, de Ferranti S, Despres JP, Fullerton HJ, Howard VJ, Huffman MD, Judd SE, Kissela BM, Lackland DT, Lichtman JH, Lisabeth LD, Liu S, Mackey RH, Matchar DB, McGuire DK, Mohler ER, 3rd,, Moy CS, Muntner P, Mussolino ME, Nasir K, Neumar RW, Nichol G, Palaniappan L, Pandey DK, Reeves MJ, Rodriguez CJ, Sorlie PD, Stein J, Towfighi A, Turan TN, Virani SS, Willey JZ, Woo D, Yeh RW, Turner MB, American Heart Association Statistics C, Stroke Statistics S (2015) Heart disease and stroke statistics−−2015 update: a report from the American Heart Association. Circulation 131, e29–322. [PubMed: 25520374]

Table 1.

Participant Characteristics, Blood Pressure Values, and Decision Making

	Values*	Minimum, Maximum
Participant Characteristics		
Age (years)	81.1±7.4	58.8, 100.7
Sex (female), n, %	687, 75.6	
Education (years)	15.4±3.0	5, 28
Diabetes Status (met criteria), n, %	181, 19.9	
Cumulative Vascular Disease Burden	0.38±0.68	0, 4
Global Cognitive Functioning	0.23±0.51	−1.56, 1.63
Blood Pressure Values		
Systolic Blood Pressure (mmHg)	133.2±19.1	84.0, 215.5
Diastolic Blood Pressure (mmHg)	77.3±11.3	50.0, 122.5
Mean Arterial Pressure (mmHg)	95.9±12.8	62, 153.5
Pulse Pressure (mmHg)	55.9±13.7	23.5, 106.0
Anti-Hypertensive Medication (use), n,%	634, 69.8	
Decision Making		
Total Decision Making	7.8±2.6	0, 12
Health Decision Making	4.1±1.5	0, 6
Financial Decision Making	3.6±1.4	0, 6

*Data indicates mean±standard deviation unless otherwise noted.

Note: Total decision making is the average of health and financial decision making scores.

Table 2.

Correlation of Key Participant Characteristics and Blood Pressure Values

	Systolic Blood Pressure (mmHg)	Mean Arterial Pressure (mmHg)	Pulse Pressure (mmHg)
Age (years)	**0.07 (0.03)**	**−0.08 (0.01)**	**0.27 (<0.0001)**
Education (years)	**−0.08 (0.01)**	−0.04 (0.21)	**−0.11 (0.0005)**
Cumulative Vascular Disease Burden	−0.002 (0.93)	−0.05 (0.07)	**0.08 (0.007)**
Global Cognitive Functioning	**−0.10 (0.001)**	−0.04 (0.22)	**−0.15 (<0.0001)**
Total Decision Making	**−0.13 (<0.0001)**	**−0.08 (0.01)**	**−0.16 (<0.0001)**
Health Decision Making	**−0.12 (0.0002)**	**−0.06 (0.04)**	**−0.16 (<0.0001)**
Financial Decision Making	**−0.11 (0.0004)**	**−0.07 (0.02)**	**−0.14 (<0.0001)**
Systolic Blood Pressure	--	**0.91 (<0.0001)**	**0.81 (<0.0001)**
Mean Arterial Pressure			**0.50 (<0.0001)**

Note: Values are Pearson correlation coefficient (p-value). Bolded values met significance set at p<0.05.

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Table 3.

Associations of Total Decision Making with Blood Pressure Values

Adjusted for:	Systolic Blood Pressure (mmHg) Core	Systolic Blood Pressure (mmHg) Fully adjusted	Mean Arterial Pressure (mmHg) Core	Mean Arterial Pressure (mmHg) Fully adjusted	Pulse Pressure (mmHg) Core	Pulse Pressure (mmHg) Fully adjusted
Age	0.09 (0.08, p=0.29)	0.09 (0.09, p<0.00001)	−0.19 (0.06, p=0.001)	−0.18 (0.06, p=0.002)	0.43 (0.06, p<0001)	0.41 (0.06, p<0001)
Sex	−0.50 (1.50, p=0.73)	−0.75 (1.53, p=0.62)	−2.04 (1.01, p=0.04)	−2.12 (1.02, p=0.04)	2.35 (1.04, p=0.02)	2.05 (1.06, p=0.052)
Education	−0.24 (0.22, p=0.28)	−0.18 (0.23, p=0.43)	−0.01 (0.15, p=0.92)	0.005 (0.15, p=0.97)	−0.34 (0.15, p=0.02)	−0.28 (0.16, p=0.08)
Total Decision Making	**−0.76 (0.26, p=0.004)**	**−0.65 (0.30, p=0.03)**	**−0.48 (0.17, p=0.006)**	**−0.42 (0.20, p=0.03)**	**−0.41 (0.18, p=0.02)**	**−0.34 (0.21, p=0.09)**
Anti-Hypertensive Medication Use		1.26 (1.43, p=0.37)		0.42 (0.95, p=0.66)		1.27 (0.98, p=0.20)
Diabetes Status		1.49 (1.61, p=0.35)		0.32 (1.08, p=0.76)		1.7 (1.11, p=0.11)
Cumulative Vascular Disease Burden		−0.99 (0.97, p=0.30)		−0.97 (0.65, p=0.13)		−0.03 (0.67, p=0.95)
Global Cognition		−1.17 (1.56, p=0.45)		0.81 (1.04, p=0.43)		−0.53 (1.08, p=0.61)

Note: Values are unstandardized coefficient (SE, p-value) from linear regression models with significance set at $p<0.05$.