OPEN

The Cognitive Impact of Chronic Diseases on Functional Capacity in Community-Dwelling Adults

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ABSTRACT

Background: People with chronic diseases may experience poor cognitive functioning associated with advanced age, progression of disease, or other comorbid chronic conditions. Empirical evidence of this phenomenon is limited despite the clinical relevance of cognitive decline and associated adverse outcomes such as poor physical functioning.

Purpose: The purpose of this study was to examine cognitive functioning in the domains of memory, attention, and executive function and its association with functional capacity in a sample of community-dwelling adults with a spectrum of chronic diseases.

Methods: An exploratory cross-sectional study was conducted in a sample of community-dwelling adults with chronic diseases, including hypertension (58.9%), diabetes mellitus (DM; 20.0%), and dyslipidemia (14.4%). Participants' mean age was 64.1 ± 11.2 years, and 48.9% were male. Ninety persons completed the face-to-face interviews, which evaluated cognitive functioning in the domains of memory, attention, and executive function using neuropsychological tests and the physical well-being test, which measured functional capacity using the Duke Activity Status Index.

Results: Compared with those with other chronic diseases, our sample with hypertension and DM had significantly more memory loss and poorer executive function. These significant differences were nullified when adjusting for age, gender, and education. Approximately one third had functional limitations ($n = 29$, 32.2%), using a cutoff point of 35 or less (Duke Activity Status Index). Memory loss (delayed recall, $b = 1.5$, $p = .016$) and poor executive function (Trail Making Test Part A, $b = -0.2$, $p < .001$) were predicting factors of functional decline, independent of age, gender, education, and comorbidity.

Conclusions/Implications for Practice: Cognitive function, particularly memory and executive function, was poorer among chronically ill Korean adults in the community with hypertension or DM than their counterparts. Functional decline was worse in the presence of memory loss and poor executive function. Studies examining the mechanism by which overall functioning is impacted by cognitive decline and its relevance to functional declines in a larger representative sample are warranted.

KEY WORDS:
cognition, functional capacity, community dwelling adults, chronic disease.

Introduction

Cardiometabolic risk control and the prevention of cardiovascular disease (CVD) are worldwide concerns (Chatterjee et al., 2012). Over the past few decades in South Korea, cardiovascular and metabolic risks have increased, with one fourth of the adult population having risk conditions such as obesity, hypertension, or diabetes mellitus (DM; E. Park & Kim, 2015). These circumstances increase the population's susceptibility to serious chronic conditions, particularly CVDs and stroke (Elias, Goodell, & Dore, 2012), which are the leading causes of death and hospital discharge in Korea (Korean Statistical Information Service, 2016).

Chronically ill persons with these conditions may experience poor cognitive function, which may be associated with advanced age, the disease itself, or comorbid conditions (Chodosh, Miller-Martinez, Aneshensel, Wight, & Karlamangla, 2010; Raphael, Wei, Greene, Baird, & Beddhu, 2012; Schneider, Kielstein, Braverman, & Novak, 2015). Prior studies have shown associations between hypertensive and/or diabetic conditions and cognitive decline (Elias et al., 2012; Manolio, Olson, & Longstreth, 2003; Roberts et al., 2014), particularly hypertension-related structural and functional changes in the brain as well as cerebral perfusion and cognition, which may indicate chronic cerebral hypoperfusion as a probable mechanism (Birns & Kalra, 2009; Elias et al., 2012; Manolio et al., 2003). Activation of associated mechanisms such as vascular risks of uncontrolled hypertension or midlife onset of DM or lifestyle risks or aging, which often occur during the development of such conditions, has been found to increase susceptibility to advanced CVDs and stroke, particularly in elderly populations (Birns & Kalra, 2009; Eggermont et al., 2012; Roberts et al., 2014). These types of cognitive decline often impede the decision making

necessary for adhering to intricate therapeutic regimens (Angermann, Frey, & Ertl, 2012; Eggermont et al., 2012; Schneider et al., 2015). Subsequently, poor adherence frequently results in adverse outcomes, including further functional decline or mortality (O'Donnell et al., 2012; Raphael et al., 2012; Schneider et al., 2015)

Despite the likelihood of cognitive decline, which may be a confounding condition in the management of chronic diseases (Eggermont et al., 2012; Hung, Wisnivesky, Siu, & Ross, 2009), there are currently limited evidence-based data on investigations of cognitive function and/or its relevance to clinical outcomes in chronic diseases (Raphael et al., 2012; Scanlan et al., 2007). Previous studies have been limited by multiple factors, including global measures used for cognitive assessment, design deficiency for investigating the relationship between cognitive function and hypertension and/or DM, and limited evidence on the functional implication of cognitive decline. Past studies have used a screening measure rather than a neuropsychological test battery that is designed to capture specific domains of cognitive impairment. In addition, few studies have explored which types of debilitating chronic diseases are more likely to be susceptible to cognitive decline. Thus, the extent of cognitive problems has not been explicated in a population experiencing hypertension and/or DM as compared with other chronic conditions. Furthermore, few community-based evaluations of cognitive decline prevalent in the senior population with various chronic conditions and its functional relevance have been conducted. Thus, there needs to be more evidence explaining the functional implication of cognition.

To address the limitations of past studies and to fill the current gap in knowledge, this study aimed to evaluate the cognitive function of community-dwelling adults with hypertension or DM as compared with other chronically ill persons who are not experiencing these two conditions. Given the theoretical and empirical evidence that has shown a cognitive decline associated with the circulatory insufficiency in hypertensive and/or diabetic conditions and its relevance to health outcomes, hypothetical relationships were established using neuropsychological tests to examine specific cognitive end points and the functional implication of cognitive decline in chronically ill elderly persons. The specific aims of this study were to (a) examine the levels of cognitive function in the domains of memory, attention, and executive function in a sample of community-dwelling adults with a spectrum of chronic diseases; (b) compare differences in each domain of cognitive function across types of chronic conditions (group with hypertension or diabetes vs. other chronically ill groups); and (c) examine the cognitive influence on functional decline in a spectrum of chronic diseases.

Methods

Study Design and Subjects

This study was part of a larger study that was designed to investigate cognitive functioning in patients with heart failure, comparing healthy and chronically ill persons. We used a descriptive comparative study design with a subsample of chronically ill persons who were living in the community but who did not have heart failure. Participants were recruited from a single province in South Korea with the following criteria: (a) aged 21 years or older, (b) have chronic health conditions but not diagnosed with heart failure, and (c) understands the study protocol. Participants with a history of cognitive inflicted disorders such as stroke, dementia, and Alzheimer's disease were excluded from this study.

This study was approved by the institutional review board (IRB) of Jeju University (JJNU-IRB-2015-011). All of the participants signed a written informed consent statement. Using a standardized training manual, the investigators, all of whom had expertise in neuropsychological evaluation and nursing research, trained a graduate nursing student and assessed whether the trainee could follow the standardized training manual. After certification by the investigators, this nursing student conducted face-to-face interviews; administered neuropsychological tests to evaluate cognitive function, physical functioning, and comorbidity; and collected sociodemographic information.

Data Collection and Measurements

After IRB approval, data were collected from August 4, 2015, to December 7, 2015. To examine the conceptual relationships of this research to determine the functional implication of cognitive decline, data on functional capacity and neuropsychological tests for cognitive function and comorbidity as a covariate, which may explain the cognitive decline often found in chronically ill persons, were obtained using the following measures.

Functional capacity

The Duke Activity Status Index (DASI) in the Korean language is designed to measure functional capacity (Hlatky et al., 1989). The DASI evaluates the extent to which an individual is able to perform a variety of daily physical activities. The DASI consists of 12 items on a dichotomous response option, with weighted values assigned for each particular activity. The total possible score ranges from 0 to 58.2, with higher scores indicating greater functional capacity. The reliability was supported by acceptable Cronbach alphas of .86 (Dunbar et al., 2009) to .93 (Coutinho-Myrrha et al., 2014); validity was also reported by investigation of a significant correlation between DASI category (DASI $\leq$ 35 and > 35) and abnormal myocardial perfusion imaging (χ^2 = 20.1, p < .001) in samples with heart disease (Prabhakar, Vido, & Poornima, 2013).

Cognitive function

Cognitive function was measured using the Seoul Neuropsychological Screening Battery II, the most common test battery for a multidimensional evaluation of cognitive function in Korea with documented validity and reliability (Kang, Jang, & Na, 2012). This battery involves multiple tests

for memory, attention, and executive function. The authors' guidelines for scoring each dimension of the neuropsychological tests were as follows.

Memory function was assessed using the Seoul Verbal Learning Test. In this test, a list of 12 words is orally presented to the patients three times. After each trial, the patients are asked to recall and repeat the words regardless of order (immediate recall memory, range = 0–36). Twenty minutes after completing the third trial, patients were asked to recall as many of the 12 words previously presented as possible (delayed recall, memory range = 0–12).

To measure attention, the Digit Span Test (forward and backward) was administered. In this test, a series of numbers, beginning with three numbers, is spoken a second apart, presented, and then immediately repeated in the same order (forward). The test continues with an increase of one number each time until the order of the numbers is incorrect. The backward test follows the same pattern, but the immediate repetition of the numbers should be backwards, beginning with the last number heard. Scores are based on the longest raw forward (range = 0–9) and backward (range = 0–8) numbers (Kang et al., 2012).

To evaluate executive function, letter/phonemic verbal fluency, which is part of the Controlled Oral Word Association test measures, was administered. Three letters were presented to the patients, after which patients were asked to generate as many words as possible using a given letter in 60 seconds. The sum of words generated for each trial was used to determine the level of word fluency, with higher scores indicating greater executive function (Kang, Chin, Na, Lee, & Park, 2000). The Korean Trail Making Test for the Elderly Parts A and B were also administered to assess frontal lobe/executive function (J. S. Park et al., 2007). Given a separate page, participants were asked to connect circled numbers in order (Part A) and to connect circled numbers and days of the week in alternate order (i.e., number–day–number–day; Part B) as quickly as possible, with a maximum of 300 seconds provided to complete each task. The measures of analysis include completion of the task within a limited time and time to completion.

Comorbidity
The Charlson Comorbidity Index (CCI), a measure of multiple comorbidity, was developed to classify prognostic comorbidity (Charlson, Pompei, Ales, & MacKenzie, 1987). The CCI involves 19 medical conditions, each having a weighted value of 1, 3, or 6 points based on severity. Possible scores were a sum of weighted values ranging from 0 to 34, with higher scores indicating a greater number of comorbid conditions. Prior studies have reported the validity and reliability of this index (Charlson et al., 1987; de Groot, Beckerman, Lankhorst, & Bouter, 2003), with a recent summary report indicating the CCI as a reliable measure evaluated by interrater and test–retest indices and a valid measure evaluated by its good prognostic value for mortality (Quan et al., 2011; Roffman, Buchanan, & Allison, 2016).

Data Analysis
In this study, descriptive statistics were performed to identify the characteristics of the study sample, including mean, standard deviation, and frequency. Descriptive statistics were also computed to examine the levels of cognitive function in the domains of memory, attention, and executive function as well as functional capacity. Student t tests and analysis of covariance were performed to compare cognitive functional score differences in each domain, including memory, attention, and executive function, between those with and without the chronic vascular diseases of hypertension and DM with or without age, gender, and education adjustment, respectively. Multiple regression analysis was also performed to examine the impact of each cognitive factor on functional decline in chronic diseases, which may predict physical functional capacity independent of age, gender, education, and comorbidity as covariates in chronic diseases. Data analyses were performed using SAS Version 9.4, and the level of significance was set at .05.

A sample size of 90 was justified based on the regression equation model testing (Aim 3) using G-power 3.0 (Faul, Erdfelder, Lang, & Buchner, 2007). A minimum sample size of 70 was estimated, given an effect size of 0.2, an alpha of .05, and a power of 0.80, with five variables entered as independent variables in separate regression equation model testing.

Results
Ninety community-dwelling persons with chronic conditions participated and completed face-to-face interviews for neuropsychological tests for cognitive assessment. The mean age was 64.1 (± 11.2) years, with a range of 25–85 years. There were 44 men (48.9%) and 46 women (51.1%), and 65 (72.2%) were married. Approximately two thirds (68.9%) had less than a high school education. The major self-reported chronic illnesses were either hypertension (40.0%) or DM (10.0%) only, a concomitant presence of both (8.9%), either hypertension or diabetes with other conditions (11.1%), dyslipidemia (14.4%), and other conditions (15.6%), which included osteoarthritis, rheumatoid arthritis, gastric ulcers, Hepatitis B, and peripheral neuropathy (but not hypertension, DM, or dyslipidemia). Older men had a higher incidence of hypertension and DM than other chronic diseases (Table 1).

Cognitive Function and Functional Capacity in Chronic Diseases
The cognitive functioning scores and functional capacity in each domain in a sample of community-dwelling adults with a spectrum of chronic diseases are shown in Table 2 (Aim 1). Immediate and delayed recall memory function were 15.1 (± 5.4) and 5.2 (± 2.3), respectively. Forward and backward attention scores were 5.8 (± 1.5) and 3.1 (± 1.1), respectively. The score of executive function, as measured using the Controlled Oral Word Association, was 23.6 (± 13.7).

TABLE 1.

Demographic and Disease-Related Characteristics of the Sample

Variable	Total (N = 90)		Hypertension/DM (n = 63[a])		Other Illness[b] (n = 27[c])		χ²	p
	n	%	n	%	n	%		
Age (years), *M* and *SD* (range = 25–85 years)	64.1	11.2					17.4	< .001
< 65	40	44.4	19	30.2	21	77.8		
≥ 65	50	55.6	44	69.8	6	22.2		
Gender							14.2	< .001
Male	44	48.9	39	61.9	5	18.5		
Female	46	51.1	24	38.1	22	81.5		
Marital status							0.6	.435
Married	65	72.2	44	69.8	21	77.8		
Unmarried	25	27.8	19	30.2	6	22.2		
Education							3.7	.150
Elementary school	44	48.9	35	55.5	9	33.3		
Middle school	18	20.0	11	17.5	7	25.9		
High school and over	28	31.1	17	27.0	11	40.8		
Comorbidity[d] (range = 0–3)							10.2	.006
0	61	67.8	43	68.2	18	66.7		
1	8	8.9	2	3.2	6	22.2		
2 and higher	21	23.3	18	28.6	3	11.1		

Note. DM = diabetes mellitus.
[a]A sample size of 63 was composed of hypertension only (*n* = 36), diabetes mellitus (*n* = 9), a concomitant presence of hypertension and diabetes mellitus (*n* = 8), and either hypertension or diabetes with other conditions (*n* = 10). [b]Diseases that were self-reported by participants with dyslipidemia, osteoarthritis, rheumatoid arthritis, gastric ulcer, Hepatitis B, or peripheral neuropathy. [c]A sample size of 27 was composed of dyslipidemia (*n* = 13) and other diseases including osteoarthritis, rheumatoid arthritis, gastric ulcer, Hepatitis B, or peripheral neuropathy, other than hypertension or diabetes mellitus (*n* = 14). [d]Assessed by the Charlson Comorbidity Index.

Furthermore, 88 (97.8%) and 75 (83.3%) participants succeeded in TMT Parts A and B within the 300-second time limit, respectively; mean times to complete the two parts were 35.1 (± 19.7) and 83.8 (± 47.5) seconds, respectively; and the mean score of functional capacity was 42.2 (± 13.9).

Comparisons of Cognitive Function and Functional Capacity by Chronic Disease Type

Comparing cognitive function between persons with hypertension or DM (*n* = 63) and other chronically ill persons

TABLE 2.

A Comparison of Cognitive Functioning Scores and Functional Capacity Between Participants With Hypertension/DM and Participants With Other Chronic Diseases

Variable	Total (N = 90)		Hypertension/ DM (n = 63)		Other Illness (n = 27)		t Test		ANCOVA[a]	
	Mean	SD	Mean	SD	Mean	SD	t	p	F	p
Cognitive functions										
SVLT immediate	15.1	5.4	13.9	4.9	18.1	5.4	3.66	< .001	2.04	.157
SVLT delayed	5.2	2.3	4.7	2.2	6.4	2.0	3.45	.001	0.65	.421
DST_F	5.8	1.5	5.6	1.5	6.2	1.3	1.65	.102	0.01	.982
DST_B	3.1	1.1	3.0	1.1	3.3	1.2	1.24	.217	0.02	.900
COWA	23.6	13.7	22.3	14.0	26.6	12.7	1.37	.174	0.31	.581
TMT-A, time	35.1	19.7	38.0	22.0	28.1	9.9	−2.95	.004	2.83	.096
TMT-B, time	83.8	47.5	93.4	48.8	65.5	39.6	−2.51	.014	0.88	.351
Functional capacity	42.2	13.9	39.5	4.4	48.5	10.6	2.92	.005	0.50	.484

Note. DM = diabetes mellitus; SVLT = Seoul Verbal Learning Test; DST_F = Digit Span Test Forward; DST_B = Digit Span Test Backward; COWA = Controlled Oral Word Association; TMT-A = Trail Making Test, Part A; TMT-B = Trail Making Test, Part B; ANCOVA = analysis of covariance.
[a]Age, gender, and education were adjusted as covariates.

without hypertension or DM (*n* = 27; Aim 2), the domains in which those with hypertension or DM showed significantly poorer performance than their counterparts with no hypertension/DM were memory (both immediate and delayed memory) and executive function (TMT Parts A and B). There was a significant difference in functional capacity, with persons with hypertension or DM showing poorer functional capacity than their counterparts with no hypertension/DM (*p* < .05; Table 2). After adjusting for age, gender, and education, no statistical significance was observed in most domains of cognitive function and functional capacity between the two groups (*p* > .05; Table 2).

Impact of Cognitive Function on Functional Decline

The mean score of functional capacity was 42.2 (± 13.9), with approximately one third having functional limitation (*n* = 29, 32.2%), using a cutoff point of 35 or less. A series of multiple regression analyses was conducted to examine the relationships between cognitive function and functional capacity (Aim 3), with age, gender, education, and comorbidity used as covariates and each cognitive function variable in the regression equation models consisting of 90 cases (except for the model of executive function, due to its involving complete cases and a time limit of 300 seconds). Regression models involving memory ($F(5, 84) = 24.89$, *p* < .001, R^2 = .60) and executive function (TMT-A; $F(5, 82) = 28.31$, *p* < .001, R^2 = .63) were significant, with relevance to functional decline in community-dwelling persons with chronic diseases. Each model accounted for 60% and 63% of the variances in functional capacity, respectively. The functional capacity increased by 1.5 points with every increase in delayed recall memory (*b* = 1.5, *p* = .016), whereas functional capacity decreased by 0.2 with every 1-second decrease in speed on executive functional performance (*b* = −0.2, *p* < .001), independent of age, gender, education, and comorbidity (Table 3).

Discussion

This study is one of only a few studies that aimed to conduct a comprehensive cognitive assessment using a neuropsychological test battery and to assess its functional impact in community-dwelling persons with various types of chronic diseases. Performance on most cognitive measures was poorer in the presence of hypertension or DM as compared with other chronic conditions. However, these significant differences were nullified when adjusting for age, gender, and education. Poor cognitive performances were also an independent predictor of functional limitation, particularly memory loss and poorer executive function, which affected the functional capacity of participants in this sample.

In this study, hypertension, with or without DM, was the most prevalent condition, and the concomitant presence of both conditions was known to increase the risk for development of cardiovascular and cerebral disease (Lago, Singh, & Nesto, 2007; Mozaffarian et al., 2015). Cognitive decline associated with these conditions has been reported (Elias et al., 2012; Manolio et al., 2003; Roberts et al., 2014). However, evidence is still lacking regarding whether cognitive function is exceedingly constrained in these conditions as compared with other chronic conditions, which limits our understanding of the probable mechanism of low cerebral perfusion in hypertension and/or DM (Birns & Kalra, 2009; Manolio et al., 2003). Therefore, a particular interest of this study was whether cognitive deficits exhibited differing effects based on type of chronic illness and community-dwelling adults with hypertension or DM versus other chronically ill persons. Many patients with hypertension or DM showed greater cognitive dysfunction, including memory loss and poorer executive function, than those with other chronic conditions in this study. Such differential cognitive functioning scores provide important insights into the cognitive impact of the chronic disease process itself, particularly high blood pressure (BP) or DM. This is consistent with the previous but limited evidence showing that hypertension

TABLE 3.

Impact of Cognitive Function on Functional Capacity in Participants With Chronic Diseases, After Adjusting for Age, Gender, Education, and Comorbidity

Variable[a]	Regression Model (*n* = 90)				Regression Model[b] (*n* = 88)			
	b	β	*t*	*p*	*b*	β	*t*	*p*
Age (years)	−0.5	−.4	−3.7	< .001	−0.6	−.5	−4.5	< .001
Gender	−1.7	−.1	−0.8	.425	0.1	.0	< 0.1	.967
Education (years)	0.7	.2	1.8	.071	0.6	.2	1.6	.120
Comorbidity	−2.9	−.1	−1.4	.172	−3.2	−.1	−1.6	.119
Delayed recall memory	1.5	.2	2.5	.016				
Frontal executive function[b] (TMT-A, time)					−0.2	−.3	−4.2	< .001

Note. TMT-A = Trail Making Test, Part A.
[a]Age, gender, education, and comorbidity were covariates with each cognitive variable as independent variables were computed in a series of regression models; each model was an independent regression model that included a specific cognitive variable of interest, memory and frontal cognitive function, respectively. Other regression models were not significant. [b]There were two missing values from those who did not complete the frontal executive function.

and/or DM is also more likely to increase susceptibility to cognitive decline if left untreated or uncontrolled (Birns & Kalra, 2009; Brady, Spiro, & Gaziano, 2005; Roberts et al., 2014), particularly with concomitant occurrence in those who are middle aged and older (Roberts et al., 2014). For example, in a previous study investigating the relationship between high BP and cognitive function using a comprehensive cognitive function test among community-dwelling elderly men, significantly poorer cognitive function was found. This was particularly the case with verbal fluency and immediate recall memory, which were found to have an independent impact attributable to age among those with uncontrolled hypertension when compared with normotensive elderly men (Brady et al., 2005).

However, after adjustment for age, gender, and education, the noted effects of hypertension or DM on cognitive function decreased. A possible reason is hypertensive status or pharmacologic treatment, which lies beyond the scope of investigation in this study. Previously, uncontrolled hypertension was found to impact cognitive deficits significantly (Brady et al., 2005), whereas its heterogeneous impact varied depending on measures or treatments used for cognitive assessment and antihypertensive regimens, respectively (Birns & Kalra, 2009). Cognitive decline in chronic diseases, particularly in cases of hypertension or DM, remains unclear and controversial. The etiology of cognitive decline is unknown but may be associated with chronic hypocerebral perfusion and secondary ischemic brain damage (Birns & Kalra, 2009; Roberts et al., 2014). Hypertension, DM, or both, particularly after midlife, are causes of advanced cardiovascular and cerebral diseases and are associated with extensive cognitive comorbidity.

In fact, cognitive deficits become more substantial in advanced CVDs such as heart failure, with patients exhibiting impairment in two or more domains that often involve, but are not limited to, global function, working memory, memory, and executive function (Kim, Hwang, Shim, & Jeong, 2015; Kim, Pressler, & Groh, 2013; Pressler et al., 2010). Cognitive impairment in cases of heart failure has been documented as being attributable to structural and functional change from cerebral ischemic damage over the long-standing progression of the disease (Almeida et al., 2012; Angermann et al., 2012; Woo et al., 2009). The mechanism for the cause of cognitive decline among those with hypertension and/or DM remains unclear. Further study is warranted to guide practice in assessing these problems in patients with hypertension and/or DM when BP and glucose control may positively impact cognitive function, particularly among aging populations where cognitive decline is already an issue. Such vascular risk control (BP, DM) in turn is likely to be beneficial to control the development of CVD as well as to have positive cognitive effects (Birns & Kalra, 2009).

Previous studies have rarely addressed the functional implications of impaired cognition in adults with chronic diseases in community settings. In this study, such cognitive deficits adversely affected chronically ill persons in the community, preventing their engaging in daily physical activity. Func-

tional limitations, indicated by a DASI score of 35 or less, were found in one third (32.2%) of the participants who were limited in performing their daily activities, whereas 67.8% were physically capable. Functional limitations imposed by cognitive function were identified, with a noticeable cognitive decline found in delayed recall memory (lower scores) and frontal executive function (slower speed) among community-dwelling persons with chronic diseases, independent of age, gender, education, and comorbidity. Consistently, limited evidence has been provided by prior studies with regard to poor cognitive function and/or its relevance to functional decline in patients with chronic diseases (Chodosh et al., 2010; Scanlan et al., 2007). A cognitively poor sample of chronically ill older Americans showed limited daily activities to be associated with poorer cognitive function, particularly in terms of lower recall memory (Chodosh et al., 2010). In addition to the functional decline associated with cognitive decline, its adverse impact on other health outcomes, including cardiac events, has been documented in chronically ill patients (O'Donnell et al., 2012; Raphael et al., 2012). For example, cardiovascular events occur more often and are associated with cognitive decline in those who earned a Mini-Mental State Examination score of less than 24 during a follow-up with a median of 56 months (O'Donnell et al., 2012). Moreover, this impairment has been shown to contribute to the low adherence of many patients with heart failure to complex self-care regimens (Kim et al., 2015). The burdens that cognitive impairment places on health suggest that cognitive impairment should be considered in care plans for the management of physical functional decline and the prevention or delay of adverse outcomes in persons at risk.

In conclusion, significantly poorer cognitive function was found in our sample of chronically ill, community-dwelling seniors with hypertension and/or DM in the domains of memory and executive function in comparison with their peers who had other conditions. However, these cognitive functional differences were negligible after adjusting for age and education. Thus, further research is necessary to determine the nature of the coexistence of cognitive impairment and chronic debilitating conditions in clinical and nonclinical samples. The connection between cognitive comorbidity and physical and psychological end points is also critical to our understanding of the treatment needs of our most vulnerable aging population.

The limitations of this study include the following. Validation of cognitive assessment in samples with chronic diseases is needed. A larger sample of impaired clinical and nonclinical older adults is needed. It is beyond the scope of this study and it remains unclear whether cognitive decline is affected by cardiometabolic disease or is associated with the progression of this disease. A comparative study using age- and gender-matched healthy participants has the potential to provide further evidence about the role of cardiometabolic disease. A Type I or II error inflation may have affected this study because of the uneven distribution of the two groups (Polit, 2010). In particular, unequal group sizes may lead to

undetected functional differences in attention and verbal fluency. Such a methodology issue like a large imbalance of group distributions is more likely to result in decreased statistical power, leading to a reduced sensitivity to detecting group differences and an increase in the risk of Type II error (Grove, Burns, & Mohnkern, 2009; Kikvidze & Moya-Laraño, 2008). Therefore, further validation of our research findings is warranted. The present sample consisted of persons with chronic diseases who lived in only one area of Korea, which limits the generalization of the results. Finally, as this study used a cross-sectional design, the extent to which cognitive function changes may be beneficial, with or without treatment of the underlying illnesses, is impossible to determine.

Given the prevalent comorbid condition of cognitive impairment in severe chronic illness, studies of the linkages between these conditions will be critical in determining which assessment and treatment programs are needed. The results offer some empirical evidence on these linkages and investigate the role of deficits in functional capacity. The findings of this study have several practical implications that offer guidance to both public and clinical practice. First, providing cognitive screening in routine primary care or in the community for persons who are susceptible to chronic illness may facilitate earlier detection of cognitive decline, especially in patients with hypertension or DM, and may improve adherence to therapeutic regimens with cognitively tailored care (Almeida et al., 2012; Angermann et al., 2012; Schneider et al., 2015). Second, this study further offers important insights for controlling hypertension and/or diabetic conditions, which may enhance the prevention of initial as well as subsequent cardiovascular incidences such as CVDs, stroke, and induced cognitive impairment (Birns & Kalra, 2009). Third, as cognitive function is a modifiable factor that influences health outcomes, more empirical evidence is necessary to better address the problem of mild cognitive impairment and its impact on outcomes in high-risk groups.

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