religions

MDPI

Article

Biobehavioral Examination of Religious Coping, Psychosocial Factors, and Executive Function in Homebound Older Adults

Lisa Boss *, Sandy Branson, Stanley Cron and Duck-Hee Kang

The University of Texas Health Science Center at Houston, School of Nursing, 6901 Bertner Avenue, Houston, TX 77030, USA; Sandra.m.branson@uth.tmc.edu (S.B.); Stanley.cron@uth.tmc.edu (S.C.); Duck-hee.kang@uth.tmc.edu (D.K.)

* Correspondence: Lisa.boss@uth.tmc.edu; Tel.: +1-713-500-2146

Academic Editor: Christine A. James

Received: 7 January 2016; Accepted: 18 April 2016; Published: 26 April 2016

Abstract: Introduction: Although many homebound older adults cope well using various resources, including religious coping strategies, some experience prolonged and unresolved psychosocial distress resulting in biological disruptions, such as hypercortisolism and increased inflammation, which are suggested mechanisms of decreased executive function. Purpose: To examine relationships of religious coping, psychosocial factors (stress, depression, loneliness), salivary biomarkers (cortisol, C-reactive protein (CRP), Interleukin-1β), and executive function. Methods: Data were collected cross-sectionally from 88 older adults (mean age 75.3). Religious coping, stress, depression, loneliness, and cognitive function were measured with standardized instruments, and saliva samples were collected for salivary cortisol, CRP, and IL-1β. Results: Negative religious coping significantly and positively correlated with stress, depression, and loneliness ($r = 0.46$, $r = 0.21$, $r = 0.47$, all $p < 0.05$); positive religious coping significantly and negatively correlated with depression and loneliness ($r = -0.29$, $r = -0.23$, both $p < 0.05$); and greater loneliness significantly predicted greater CRP ($p < 0.05$). For executive function, IL-1β showed a significant positive correlation ($r = 0.23$, $p = < 0.05$). Discussion: Our findings fill gaps related to biobehavioral interactions of religious coping and cognitive health in the aging population. Future research should include additional psychosocial and biobehavioral variables in larger samples of diverse and vulnerable populations. Collective findings may be able to identify particularly vulnerable subgroups of population, ultimately with tailored interventions to prevent cognitive decline.

Keywords: religious coping; biobehavioral; executive function; aging; homebound population

1. Introduction

With the large number of baby boomers rapidly aging in the United States, it is critical for all healthcare disciplines to consider the broad range of health and disability issues of the older adult aged 65 years and older. While many older adults are independently living in the community with few chronic health problems that are self-managed, there are about 2 million older adults who are homebound with disability, comprising 5.6% of the population aged 65 years and older [1]. For homebound older adults, typically defined as leaving the home less than once a week [2], depression and cognitive decline are the most common and devastating health concerns [3]. Being homebound also is associated with increased physical decline and increased risk of death within 2 years. Thus, homebound status in the older adult is an indicator of rapid mental and physical decline and should be the target of research and development of preventative interventions [4].

Decline in executive function is associated with the inability to perform independent activities of daily living and everyday functioning including comprehending medication instructions, handling

finances, arranging transportation, and food preparation [5]. Preserving the ability for homebound older adults to live safely and independently is a major research priority given the high prevalence and financial implications of cognitive decline. Although some homebound older adults cope well using various resources, including religious coping strategies [6], others experience prolonged and unresolved psychosocial distress resulting in biological disruptions, such as hypercortisolism and increased inflammation [7], which are suggested mechanisms of decreased cognitive function. Investigation of the effects of religious coping and other common psychological factors, such as stress, depression, and loneliness, on biological markers and cognitive function is an important research priority in the homebound population.

1.1. Religious Coping

Although religion and spiritual practices are commonly used in the elderly, their influence on health is not well understood [6]. Religious coping includes the use of religious practices as a coping mechanism against stress or any adverse life event. More specifically, negative religious coping refers to the use of negative religious coping strategies to cope with stress and may include getting angry at God (or another religious deity), blaming God, or feeling abandoned by God, whereas positive religious coping refers to the use of positive strategies, such as prayer, meditation, pastoral support, benevolent religious reframing, and religious faith to cope with a stressful situation [8]. The end result of negative religious coping is decreased capacity to manage a challenging situation or more feelings of stress, whereas the end result of positive religious coping is improved ability to manage challenging situations and less feelings of stress [8]. Published findings on religious coping and health are mixed. Some authors report that greater use of positive religious coping strategies was associated with positive psychosocial factors, such as higher self-esteem, life satisfaction, and quality of life [9], while others report significant and positive associations of negative religious coping with distress, confusion, and depression in palliative care patients, and significant positive associations of positive religious coping and severity of pain in cancer patients [10,11]. Still, other authors reported non-significant associations of positive religious coping with asthma diagnosis, and mixed findings between positive and negative religious coping and transplant-related concerns in autologous stem cell cancer patients [12,13]. Inconsistent findings suggest a need for more studies, particularly in vulnerable populations, such as homebound older adults.

1.2. Stress, Depression, and Loneliness

Homebound older adults frequently experience a number of common stressors, including chronic illness, functional impairment, and cognitive impairment [14], and the risk for feelings of stress and depression is particularly high. Both stress and depression are associated with poor health outcomes in the older adult, including greater functional and cognitive impairment [15,16], higher risk for nursing home placement [17], high health care costs [18,19], decreased quality of life [20,21], and suicide [22]. Similarly, loneliness has been associated with poor mental and physical health outcomes, including increased morbidity and mortality risk, functional limitations, and poor health practices [23–25]. Because stress, depression, and loneliness commonly occur together and alter biological responses and subsequent health outcomes, their collective relationships with biological responses and health outcomes would provide meaningful information in the care of older adults.

1.3. Biological Influence

Biological mechanisms may underlie associations between psychosocial factors and cognitive function. For example, prolonged activation of the hypothalamus-pituitary-adrenal (HPA) axis with hypercortisolism in response to prolonged stress, depression, and loneliness is directly related to reduced dendritic branching, abnormal synapse formation, and neuronal death in areas of the brain important to memory and executive function, the hippocampus and frontal cortex [26–29]. Increased inflammation is another common biological response to stress and depression [30–32] and is a potential

pathway that may impact cognitive function in the older adult [33,34] C-reactive protein (CRP) is a marker of systemic inflammation and is typically increased in stressful, age-related conditions such as cardiovascular disease, diabetes mellitus, arthritis, and cancer. In a cross-sectional study, authors reported that social isolation was associated with increased CRP [35]. Interleukin-1β (IL-1β), a major inflammatory cytokine, increases with age and during times of stress and disease. High IL-1β may damage normal synaptic function, thus impairing cognitive function [36]. Although preliminary evidence exists, clear understanding of psychosocial influence on biological responses and cognitive health in homebound older adults is unknown.

1.4. Theoretical Framework

A biobehavioral interaction model [37] was the theoretical basis for this study. In this model, the concept of health is conceptualized to be influenced by various factors within and across the individual, psychosocial, behavioral, and environmental domains. These factors are likely to interact to influence biological responses, ultimately affecting a person's mental and physical health outcomes [37]. Based on this model, primary focus was placed on the psychosocial, biological, and health outcome domains in a homebound older adult population. Religious coping, stress, depression, and loneliness within the psychosocial domain were conceptualized to directly and indirectly influence the biological responses of cortisol and inflammation (cortisol, CRP, IL-1β), which may ultimately influence the cognitive health outcome identified as executive function in this study.

1.5. Purpose and Hypothesis

The purpose of this cross-sectional study was to examine relationships and influence of religious coping and psychosocial factors (stress, depression, loneliness) on salivary biomarkers of stress and inflammation (cortisol, CRP, IL-1β) and executive function in a population of homebound older adults receiving Meals on Wheels (MOW). Extraneous factors thought to influence executive function were considered and addressed as covariates and included age, gender, education level, and body mass index (BMI) [38]. It was hypothesized that (1) negative religious coping would correlate positively with psychosocial factors and salivary biomarkers and negatively with executive function; and positive religious coping would correlate negatively with psychosocial factors and salivary biomarkers and positively with executive function; and (2) negative religious coping and greater levels of psychosocial factors would predict higher salivary biomarkers and worse executive function in the MOW population.

2. Methods

2.1. Design and Sample

In a cross-sectional study, 88 older adults participated. Sample size was calculated with power analysis based on the correlation between loneliness and executive function found in a similar population of author's previous study [39]. Based on $r = -0.30$, alpha at 0.05, and statistical power set at 0.8, a sample size of 80 participants was calculated. Inclusion criteria of the participants were $\geqslant$ 60 years of age to be consistent with the MOW service criteria, ability to read/understand English, not diagnosed with a neurodegenerative disease, and currently enrolled in the MOW program in a rural county in Texas. Exclusion criteria were inability to complete psychometric instruments as instructed, inability to provide saliva sample, and currently taking hormone replacement therapy or corticosteroids.

In order to qualify for the MOW nutritional program, seniors must be $\geqslant$60 years and without access to adequate nutrition. Most MOW recipients are primarily homebound due to physical and/or mobility limitations and are socially isolated from the community [40]. In general, MOW recipients are ethnically diverse, live below the poverty line, and perceive their health to be fair or poor [41].

Community dwelling older adults who are socially isolated, such as MOW clients, are also at high risk for stress, depression, loneliness, and cognitive decline [42,43].

2.2. Setting and Recruitment

Recruitment flyers were hand delivered by MOW volunteers to all 500 MOW clients during their routine meal delivery over the course of 8 to 10 weeks. Recruitment flyers were written at the 8th grade reading level and included basic information about the study with the researcher's contact information. Clients contacted the researcher via cellular phone as instructed on the recruitment flyer. Researchers explained the study in detail, questions were answered, and it was determined if the client was eligible for study participation. If the client was eligible and agreed to proceed, the researcher made an appointment for a home visit to explain and obtain the formal process of informed consent and data collection. Prior to data collection, the study was approved by the Committee for the Protection of Human Subjects at the University. Each participant was offered a $10 gift card upon completion of the study.

2.3. Measurement

All data were collected in the participant's home and data collection took approximately 30–45 min. Data collection was performed by trained members of the research team. Prior to saliva collection, all participants were instructed to complete psychometric instruments. If the participant was unable to independently complete psychometric instruments, the questions were read out loud by the data collector and the participant verbally reported the answers, which were then transcribed onto the instruments.

Religious coping was measured with the Brief RCOPE. The questionnaire contains 14 items designed to measure the role religious practices serve to cope with life stressors [8]. Seven items measure positive religious coping patterns, and seven items measure negative religious coping patterns. Scores on each subscale are summed, reported separately, and range from 7–28. The Brief RCOPE is considered reliable when used in adults from various cultures and religious affiliations, and Cronbach's α is 0.81 [8]. Cronbach's α was 0.72 in this study.

Stress was measured with the Perceived Stress Scale (PSS), a 10-item questionnaire designed to assess the degree to which situations in a person's life are appraised as stressful [44]. The Likert style instrument consists of easily understood questions and has been psychometrically tested in various populations. Scores are summed and a higher score indicates a higher perceived stress level with the possible score range of 0–40. The PSS is considered a reliable instrument in older adults with a Cronbach's α of 0.76 [39]. Cronbach's α was 0.83 in this study.

Depression was measured with the Geriatric Depression Scale Short Form (GDS SF), a questionnaire designed for use in the older adult population [45]. The instrument contains 15 items that are answered "yes" or "no." A score of 0–5 is normal and a score greater than 5 suggests depression [45]. Cronbach's α is adequate at 0.71 in the older adult [39]. Cronbach's α was 0.79 in this study.

Loneliness was measured with the 20-item revised University of California at Los Angeles (UCLA) Loneliness Scale designed to assess general feelings of social isolation and dissatisfaction with one's social interactions [46]. The 20-item, Likert style questionnaire contains 10 positively worded items and 10 negatively worded items. After reversing the negatively worded items, all items are summed and a total score is obtained ranging from 20 to 80. Higher scores indicate higher levels of loneliness. Considered a reliable instrument, Cronbach's α is 0.86 in the older adult population [39]. Cronbach's α was 0.91 in this study.

Executive function was measured with the CLOX I, which is designed to elicit executive function impairment [47]. Scores on the CLOX are strongly correlated with established measures of executive function, such as the EXIT25 measure [47]. On a blank sheet of paper, participants were asked to "draw a clock that says 1:45; set the hands and numbers on the face so that a child could read them". The clock

is then graded on specific scoring criteria indicated for the instrument, and points are deducted if any elements are missing or drawn incorrectly. Possible scores range from 0 to 15, and a higher score indicates better executive function. Commonly used in the older adult population, Cronbach's α is adequate at 0.86 [39]. Cronbach's α was 0.83 in this study.

Each participant provided 1–2 mL saliva between 1:00 p.m. and 5:00 p.m. to control for circadian rhythmicity. The biological sample was collected after the standardized questionnaires were completed. Most participants successfully provided saliva within 10–30 min. Saliva samples were secured in a collection tube, placed in a biohazard laboratory bag inside a secure cooler with ice, and delivered to the Biosciences Laboratory at the University. Saliva samples were stored in −80 degree Celsius until analyzed for cortisol, CRP, and IL-1β.

Biomarkers were assayed in duplicate using standardized enzyme immunoassay (EIA) kits [48]. To evaluate precision of biological measures, coefficients of variability (CV) were calculated. The intra-assay CV was calculated following manufacturer's instructions. The intra-assay CV was calculated from the duplicates of the samples and inter-assay CV was calculated from controls on different plates. *A-priori* criterion for intra-assay CV was <10% and inter-assay CV was <15%, which were met for all salivary biomarkers. Sensitivity of the EIA kit was 0.0007 μg/mL for cortisol, 10 pg/mL for CRP, and 0.6 pg/mL for IL-1β.

2.4. Data Analysis

Descriptive statistics were completed for all study variables including demographic information. Values for cortisol, IL-1β, and CRP were transformed to a natural log scale due to the data not following a normal distribution. Univariate analyses were initially conducted to test for possible associations between the psychosocial variables and the biological and health variables (cortisol, IL-1β, CRP, and cognitive function). To determine influence of religious coping, psychosocial factors, and covariates on biomarkers of stress and inflammation and executive function, independent variables with a $p < 0.10$ in the univariate analyses were included in multiple linear regression models for cortisol, IL-1β, CRP, and cognitive function. A separate model was tested for each outcome variable. The level of significance for variables in the regression models was set at $p < 0.05$. Data were analyzed using SAS 9.4 for Windows.

3. Results

3.1. Participant Characteristics

The sample was comprised of 88 MOW clients; 34% males (n = 30) and 66% females (n = 58). Age ranged from 60 to 95 years (M = 75.4, SD = 9.0) and males were slightly younger than females (M = 74.9, SD = 10.1; M = 75.6, SD = 8.5, respectively). Ninety four percent were Caucasians (n = 83), and 6% were African Americans (n = 5). Most participants were widowed (33%), and the rest were married (30%), divorced (29%), or single (8%). Many (44%) reported high school education (M = 12.3 years of education, SD = 2.25).

The average BMI was 29.6 (SD = 6.22) and BMI values ranged from 13.7 to 46.9 (males: M = 28.5, SD = 6.54; females: M = 30.6, SD = 7.7). The most commonly reported medical problems were hypertension, hypercholesterolemia, diabetes mellitus type 2, coronary artery disease, depression, and anxiety. Few participants reported thyroid problems, osteoarthritis, and migraines. Most participants reported using less than seven prescriptions per day and only a few reported daily vitamin or herbal remedy usage.

3.2. Descriptive Data for Psychosocial Factors and Biological Responses

As depicted in Table 1, overall scores for positive religious coping were high (M = 21.98), whereas overall scores for negative religious coping were low (M = 9.72). Overall scores for the PSS indicated average level of stress (M = 15.02), while scores for the GDS (M = 4.31) and R-UCLA (M = 39.9) indicated minimal depression and moderate loneliness, respectively. About 41% of participants performed

poorly on the CLOX I with the low overall scores (M = 10.23). Overall levels of cortisol ranged from 0.01 μg/dL to 5.17 μg/dL (M = 0.33 μg/dL), levels of CRP ranged from 47.0 pg/mL to 73,889.6 pg/mL (M = 6530.5 pg/mL) and levels of IL-1β ranged from 6.0 pg/mL to 5253.19 pg/mL (M = 554.86 pg/mL, SD = 872.44). When gender differences were compared for each variable, significant differences were found in PSS scores, CLOX I scores, and salivary cortisol levels (all $p \leqslant 0.05$) Men, compared with women, reported significantly lower levels of stress (p = 0.05), worse executive function (p = 0.04), and had higher salivary cortisol levels (p = 0.03).

Table 1. Descriptive data for psychometric and biologic measures (N = 88).

	Possible Range	Score Range	Mean	SD	p Value: Gender Difference
+ Relig. Coping	7–28	7–28	21.98	5.04	0.13
Males		11–28	21.03	5.00	
Females		7–28	22.93	5.76	
− Relig. Coping	7–28	7–25	9.72	3.35	0.57
Males		7–18	9.49	3.19	
Females		7–25	9.95	3.79	
Loneliness	20–80	20–67	39.9	12.22	0.71
Males		20–63	39.40	11.20	
Females		20–67	40.47	13.33	
Stress	0–40	0–38	15.02	6.21	0.05
Males		3–26	13.40	5.55	
Females		0–38	16.64	13.33	
Depression	0–20	0–13	4.31	3.02	0.07
Males		0–11	3.63	3.03	
Females		0–13	4.99	3.32	
Executive Function	0–15	3–14	10.23	3.24	0.04
Males		3–14	9.38	3.59	
Females		3–14	10.79	2.67	
Cortisol μg/dL					
Both Genders		0.01–5.17	0.33	0.76	
Males		0.03–5.17	0.58	1.30	0.03
Females		0.01–1.75	0.19	0.24	
CRP pg/mL					
Both Genders		47.0–73889.6	6530.5	13852.3	
Males		47.0–7166.1	7559.18	14829.9	0.95
Females		167.98–73889.6	5502.77	12016.73	
IL-1β pg/mL					
Both Genders		6.0–5253.19	554.86	872.44	
Males		6.0–5253.19	638.16	1142.06	0.40
Females		6.0–3592.11	485.19	607.82	

3.3. Correlations of Psychosocial and Biologic Data

Table 2 provides Pearson's coefficient r that reflect correlations between psychosocial and biologic data. Positive religious coping was significantly and negatively correlated with depression (r = −0.29, p = 0.006), and significantly and negatively correlated with loneliness (r = −0.23, p = 0.03). Negative religious coping was significantly and positively correlated with stress, depression, and loneliness (r = 0.46, r = 0.21, r = 0.47, all $p \leqslant 0.05$, respectively). Depression was the only psychosocial variable significantly correlated with executive function (r = 0.22, p = 0.04). The only significant correlations with biologic data were a positive correlation between loneliness and CRP (r = 0.26, p = 0.02), and between executive function and IL-1β (r = 0.23, p = 0.03).

Table 2. Correlation coefficients for psychometric and biologic data (N = 88).

	+ RC	-RC	Stress	Depression	Loneliness	EF	Cortisol	CRP	IL-1β
+ RC	1	0.10	−0.08	−0.29 **	−0.23 *	0.05	−0.16	−0.01	0.03
− RC		1	0.46 **	0.21 *	0.47 ***	−0.06	0.07	0.02	−0.15
Stress			1	0.64 ***	0.67 ***	0.21	0.05	0.13	0.11
Depression				1	0.63 ***	0.22 *	0.16	0.17	0.21
Loneliness					1	−0.03	0.19	0.26 *	0.13
EF						1	−0.07	−0.01	0.23 *

Note: * = $p \leqslant 0.05$; ** = $p \leqslant 0.01$; *** = $p \leqslant 0.001$; + RC = positive religious coping, − RC = negative religious coping; EF = executive function.

3.4. Psychosocial and Demographic Contributions to Biologic Responses and Cognitive Function

Table 3 includes p values for each multiple regression model. For salivary cortisol as the outcome, gender was a significant contributor (p = 0.02), with females demonstrating lower mean levels than males (0.13 *vs.* 0.22, respectively). In the same model, loneliness had a nearly significant contribution to cortisol (p = 0.06). For IL-1β as the outcome, there was a significant positive contribution by education on IL-1β (β = 0.15, p = 0.03). For CRP as the outcome, loneliness was the only significant contributor (p = 0.03), with higher loneliness scores associated with higher CRP values (β = 0.03). For executive function as the outcome, only age was identified as a significant predictor (p = 0.03), with increasing age associated with lower CLOX I scores (β = −0.08).

Table 3. Multiple regression models (N = 88).

Outcome	Predictor	β	df	*F* Value	*p* Value	Adjusted R^2
Cortisol						0.08 (Model)
	Gender (F)	−0.56	1	5.67	0.02 *	0.06
	Loneliness	0.02	1	3.79	0.06	0.04
IL-1β						0.11 (Model)
	BMI	0.03	1	1.30	0.26	0.01
	Education	0.15	1	4.64	0.03 *	0.05
	Executive Function	0.08	1	2.21	0.14	0.02
	Depression	0.08	1	2.59	0.11	0.03
CRP						0.08 (Model)
	BMI	0.04	1	3.32	0.07	0.04
	Loneliness	0.03	1	5.05	0.03 *	0.06
Executive Function						0.10 (Model)
	Gender (F)	1.21	1	3.07	0.08	0.03
	Age	−0.08	1	4.75	0.03 *	0.05
	BMI	0.04	1	1.04	0.31	0.01
	Depression	0.05	1	0.17	0.68	0.002
	Stress	0.03	1	0.26	0.61	0.003

Note: * = $p \leqslant 0.05$.

4. Discussion

The purpose of this cross-sectional, study was to examine the relationships and influence of religious coping and psychosocial factors (stress, depression, loneliness) on salivary biomarkers of stress and inflammation (cortisol, CRP, IL-1β) and executive function in a population of homebound older adults receiving MOW. Our first hypothesis that religious coping would correlate with psychosocial factors, salivary biomarkers, and executive function was partially supported. We found that negative religious coping was significantly and positively correlated with stress, depression, and

loneliness, and positive religious coping was significantly and negatively correlated with depression and loneliness. Our second hypothesis that negative religious coping and greater levels of psychosocial factors would influence higher levels of salivary biomarkers and worse executive function was partially supported with the finding that higher loneliness significantly predicted higher CRP and showed a trend for higher cortisol.

Our findings that negative religious coping significantly and positively correlated with psychosocial factors whereas positive religious coping significantly and negatively correlated with these psychosocial factors are consistent with most findings in the literature. Bosworth *et al.* [49] studied religious coping longitudinally in 114 participants over 60 years old, and reported that positive religious coping was negatively correlated with depression at baseline and follow up. Authors of a meta-analysis reported positive religious coping was negatively correlated with negative psychosocial symptoms, such as stress and depression [6]. Additional published evidence in adults indicates that the use of positive religious coping is related to higher self-esteem, life satisfaction, and quality of life, whereas less use of positive religious coping strategies is related to more stress and depressive symptoms [9]. Studies on religious coping and loneliness are lacking. In our study, positive religious coping was significantly correlated with less loneliness, whereas negative religious coping was significantly correlated with greater loneliness. These findings are not surprising considering similar findings on religious coping and other negative psychosocial variables, however, the lack of studies on loneliness and its specific relationship with religious coping is unexpected. Loneliness is a significant concern among older adults and preliminary evidence indicates that loneliness is associated with cognitive decline [50]. These findings clearly suggest the importance of the loneliness concept among older adults, particularly among socially isolated homebound older adults. Future research should include more in-depth investigation on the relationship among loneliness, religious coping, and health to build a basis for developing potential interventions.

The only variable significantly correlated with executive function in our study was IL-1β. It was surprising that, contrary to our hypothesis, IL-1β showed a significant positive association with executive function. Published evidence indicates IL-1β increases with age, as well as during times of stress and disease. Pathologically high levels of IL-1β could damage normal synaptic function and impair cognitive function [36]. In two longitudinal studies with older adults, authors reported significant and negative correlations between IL-1β and domains of cognitive function [51,52]. However, in another study with a large number of older adults, authors reported a significant positive correlations between circulating IL-1β and cognitive function, whereas IL-6 showed a significant negative correlation with cognitive function [53]. The underlying reasons for such dissociation even among typical proinflammatory cytokines in their association with cognitive function are unknown at this point, but warrant further study.

Our hypothesis that psychosocial factors (stress, depression, loneliness) would correlate negatively with executive function was not supported with our non-significant findings and positive correlation of depression and executive function. In contrast to our findings, published evidence supports the detrimental influence of both stress and depression on various domains of cognitive function in the older adult. Wilson *et al.* [54] followed a large population based cohort for 5–12 years and found that chronic psychological stress was significantly associated with increased cognitive decline in old age. Authors of another large population based cohort reported that stress was significantly associated with worse global cognitive function over a time period of 10 years [55]. Similarly, authors of two longitudinal studies reported significant correlations for adult participants with higher depression and worse executive function [56,57]. Fewer studies exist, however, that identify a link between loneliness and cognitive function. In a 10-year follow up of a large cohort of community dwelling elders, Tilvis *et al.* [58] reported that high loneliness was significantly associated with greater risk of cognitive decline at follow up. Wilson *et al.* [59] also found that lonely participants were twice as likely to experience cognitive decline at the 4-year follow-up. It is important to note, that even though we found a significant and positive correlation of depression and executive function, the mean score

for depression was low with limited variations in this sample. For this reason, our results should be interpreted with caution and additional studies are needed in this population to determine the precise relationship of all psychosocial factors and executive function.

Our hypothesis that negative religious coping and psychosocial factors would predict detrimental levels of salivary biomarkers and worsened executive function was partially supported when loneliness significantly predicted higher CRP and showed a strong trend for cortisol. Published evidence indicates that inflammation is a potential biological mechanism through which negative psychosocial factors may detrimentally impact cognitive function. Lonely individuals are highly reactive to stress, and prolonged activation of glucocorticoids may disturb normal regulatory responses to allow high levels of inflammation [7,60,61]. Because inflammation has been implicated in pathological processes involved in decreased cognitive function [62], increased inflammation in lonely individuals may be a pathway to impaired cognitive function. In a study, Rueggeberg and colleagues [63] reported that lonely adults who did not use self-protection as a coping mechanism had significantly higher CRP levels at the 6-year follow up, but cognitive function was not measured. Noble and colleagues [64], on the other hand, reported that older adults with higher CRP levels showed higher adjusted odds of impaired memory. Although the findings may vary across the studies, evidence together suggest that importance of continued investigation on biobehavioral interactions and cognitive outcomes particularly in older adults.

5. Limitations

This study has several limitations. The cross-sectional research design limits the interpretation of predictive relationships between psychosocial variables and outcomes of biomarker responses and executive function. The power calculation for sample size was based on expectation from our previous study that the correlation of loneliness and executive function would be $r = -0.30$, however our correlation between loneliness and executive function was only $r = -0.03$. Thus, we believe the sample size was too small to provide sufficient power in this study. Although our previous population was similar to the population in this study, the previous population were elderly with high socioeconomic status and living in a retirement community, whereas the current population were socially isolated homebound older adults. This is an important point to consider when planning future studies with adequate sample sizes. The current cohort was mostly homogenous and a majority of the participants were older Caucasian females with little ethnic diversity. Thus, the findings of this study do not adequately represent the general population and findings should be interpreted with caution. Biomarker measurements were a strength of this study. However, the number and type of biomarkers could have been expanded further to include other relevant hormones and anti- and pro- inflammatory biomarkers if resources and sample setting were less limited. Nevertheless, non-invasive saliva samples provided an opportunity to investigate fundamental biological pathways of glucocorticoid hormone and inflammatory markers. Despite these limitations, we present several interesting insights on relationships of religious coping, psychosocial factors, biomarkers of stress and inflammation, and executive function in this vulnerable, homebound older adult population, which can significantly contribute to the knowledge base of biobehavioral research in cognitive function.

6. Conclusions/Future Studies

The exact influence of religious coping on cognitive health is not well understood, and this is an important problem since cognitive decline is the most common and devastating health problem in homebound older adults. Main findings in our study were that negative religious coping significantly and positively correlated with stress, depression, and loneliness; positive religious coping significantly and negatively correlated with depression and loneliness; and greater loneliness significantly predicted elevated CRP levels. For executive function, IL-1β was only a significant and positive correlate. These findings are generally similar to published findings, but an unexpected relationship between executive

function and an inflammatory biomarker requires further investigation due to the complex nature of religious coping and its association with psychosocial, biological, and cognitive variables.

The findings of this study contribute to biobehavioral interactions surrounding religious coping and cognitive health in the aging population. Future research should be expanded to additional psychosocial and biobehavioral variables in larger samples of diverse and vulnerable populations. With increasing longevity, biobehavioral interactions and cognitive function will remain a significant area of research in the older adult. Collective findings may be able to identify particularly vulnerable subgroups of population ultimately with more tailored interventions to prevent cognitive decline.

Acknowledgments: This study was supported by the Dean's Research Award, 2014. The University of Texas Health Science Center at Houston.

Author Contributions: Lisa Boss, Sandy Branson, Duck-Hee Kang, and Stanley Cron had full access to all data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Lisa Boss, Sandy Branson, and Duck-Hee Kang. Acquisition of subjects and/or data: Lisa Boss and Sandy Branson. Analysis and interpretation: Lisa Boss, Sandy Branson, Duck-Hee Kang, and Stanley Cron. Drafting of the manuscript: Lisa Boss, Sandy Branson, Duck-Hee Kang, and Stanley Cron.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Katherine Ornstein, Bruce Leff, Kenneth Covinsky, Christine Ritchie, Alex Federman, Laken Roberts, Amy Kelley, Albert Siu, and Sarah Szanton. "Epidemiology of the homebound population in the United States." *JAMA Internal Medicine* 175 (2015): 1180–86. [CrossRef] [PubMed]
2. Jiska Cohen-Mansfield, Dov Shmotkin, and Haim Hazan. "Homebound older persons: Prevalence, characteristics, and longitudinal predictors." *Archives of Gerontology and Geriatrics* 54 (2012): 55–60. [CrossRef] [PubMed]
3. Wie Qiao Qiu, Michael Dean, Timothy Liu, Linda George, Margery Gann, Joshua Cohen, and Martha Bruce. "Physical and mental health of the homebound elderly: An overlooked population." *Journal of the American Geriatrics Society* 58 (2010): 2423–28. [CrossRef] [PubMed]
4. Marie Herr, Aurelien Latouche, and Joel Ankri. "Homebound status increases death risk within two years in the elderly: Results from a national longitudinal survey." *Archives of Gerontology and Geriatrics* 56 (2013): 258–64. [CrossRef] [PubMed]
5. Timothy Salthouse. "Consequences of age-related cognitive declines." *Annual Review of Psychology* 63 (2011): 201–26. [CrossRef] [PubMed]
6. Gene Ano, and Erin Vasconcelles. "Religious coping and psychological adjustment to stress: A meta-analysis." *Journal of Clinical Psychology* 61 (2005): 461–80. [CrossRef] [PubMed]
7. Michael R. Irwin. "Human psychoneuroimmunology: 20 Years of discovery." *Brain, Behavior, and Immunity* 22 (2008): 129–39. [CrossRef] [PubMed]
8. Kenneth Pargament, Margaret Feuille, and Donna Burdzy. "The Brief RCOPE: Current psychometric status of a short measure of religious coping." *Religions* 2 (2011): 51–76. [CrossRef]
9. Myleme Harrison, Harold Koenig, Judith Hays, Anedi Eme-Akwari, and Kenneth Pargament. "The epidemiology of religious coping: A review of recent literature." *International Review of Psychiatry* 13 (2001): 86–93. [CrossRef]
10. Judith Hills, Judith Paice, Jacqueline Cameron, and Susan Shott. "Spirituality and distress in palliative care consultation." *Journal of Palliative Medicine* 8 (2005): 782–88. [CrossRef] [PubMed]
11. Allen Sherman, Stephanie Simonton, Umaira Latif, Rebecca Spohn, and Guido Tricot. "Religious struggle and religious comfort in response to illness: Health outcomes among stem cell transplant patients." *Journal of Behavioral Medicine* 28 (2005): 359–67. [CrossRef] [PubMed]
12. Ethan Benore, Kenneth Pargament, and Sara Pendleton. "An initial examination of religious coping in children with asthma." *International Journal for the Psychology of Religion* 18 (2008): 267–90. [CrossRef]
13. Allen Sherman, Thomas Plante, Stephanie Simonton, Umaira Latif, and Elias Anaissie. "Prospective study of religious coping among patients undergoing autologous stem cell transplantation." *Journal of Behavioral Medicine* 32 (2009): 118–28. [CrossRef] [PubMed]

14. Andrew Petkus, Amber Gum, and Julie Wetherell. "Thought suppression is associated with psychological distress in homebound older adults." *Depress Anxiety* 29 (2012): 219–25. [CrossRef] [PubMed]
15. Vonetta Dotson, Susan Resnick, and Alan Zonderman. "Differential association of concurrent, baseline, and average depressive symptoms with cognitive decline in older adults." *The American Journal of Geriatric Psychiatry* 16 (2008): 318–30. [CrossRef] [PubMed]
16. Eric Lenze, Joan Rogers, Lynn Martire, Benoit Mulsant, Bruce Rollman, Mary Dew, Richard Schulz, and Charles Reynolds, III. "The association of late-life depression and anxiety with physical disability: A review of the literature and prospectus for future research." *The American Journal of Geriatric Psychiatry* 9 (2001): 113–35. [CrossRef] [PubMed]
17. Laura Gibbons, Linda Teri, and Rebecca Logsdon. "Anxiety symptoms as predictors of nursing home placement in patients with Alzheimer's disease." *Journal of Clinical Geropsychology* 8 (2002): 335–42. [CrossRef]
18. Emily Porensky, Mary Dew, Jordan Karp, Elizabeth Skidmore, Bruce Rollman, M. Katherine Shear, and Eric Lenze. "The burden of late-life generalized anxiety disorder: Effects on disability, health-related quality of life, and healthcare utilization." *The American Journal of Geriatric Psychiatry* 17 (2009): 473–82. [CrossRef] [PubMed]
19. Jurgen Unutzer, Donald Patrick, Greg Simon, David Grembowski, Edward Walker, Carolyn Rutter, and Wayne Katon. "Depressive symptoms and the cost of health services in HMO patients aged 65 years and older: A prospective 4-year study." *Journal of the American Medical Association* 277 (1997): 1618–23. [CrossRef] [PubMed]
20. Dan Blazer. "Depression in late life: Review, and commentary." *Journals of Gerontology Series A: Biological Sciences* 58 (2003): 249–365. [CrossRef]
21. Julie Wetherell, Steven Thorp, Thomas Patterson, Shahrokh Golshan, Dilip Jeste, and Margaret Gatz. "Quality of life in geriatric generalized anxiety disorder: A preliminary investigation." *Journal of Psychiatric Research* 38 (2004): 305–12. [CrossRef] [PubMed]
22. Carolyn Turvey, Yeates Conwell, Michael Jones, Caroline Phillips, Eleanor Simonsick, Jane Pearson, and Robert Wallace. "Risk factors for late-life suicide: A prospective, community-based study." *The American Journal of Geriatric Psychiatry* 10 (2002): 398–406. [CrossRef] [PubMed]
23. Noreen Mahon, Adela Yarcheski, and Thomas Yarcheski. "Social support and positive health practices in young adults. Loneliness as a mediating variable." *Clinical Nursing Research* 7 (1998): 292–308. [CrossRef] [PubMed]
24. Susan Nolen-Hoeksama, and Cheryl Ahrens. "Age differences and similarities in the correlates of depressive symptoms." *Psychology and Aging* 17 (2002): 116–24. [CrossRef]
25. Brenda Penninx, Theo van Tilburg, Didi Kriegsman, Dorly Deeg, Joan Boeke, and Jacques van Eijk. "Effects of social support and personal coping resources on mortality in older age: The Longitudinal Aging Study Amsterdam." *American Journal of Epidemiology* 146 (1997): 510–19. [CrossRef] [PubMed]
26. Emma Adam, Louise Hawkley, Brigitte Kudielka, and John Cacioppo. "Day-to-day dynamics of experience-cortisol associations in a population based-sample of older adults." *Proceedings of the National Academy of Sciences of the United States of America* 103 (2006): 17058–63. [CrossRef] [PubMed]
27. Elissa Epel. "Psychological and metabolic stress: A recipe for accelerated cellular aging?" *Hormones* 8 (2009): 7–22. [CrossRef] [PubMed]
28. Ettore Ferrari, and Flavia Magri. "Role of neuroendocrine pathways in cognitive decline during aging." *Ageing Research Reviews* 7 (2008): 225–33. [CrossRef] [PubMed]
29. Andrew Steptoe, Natalie Owen, Sabine Kunz-Ebrecht, and Lena Brydon. "Loneliness and neuroendocrine, cardiovascular, and inflammatory stress responses in middle-aged men and women." *Psychoneuroendocrinology* 29 (2004): 593–611. [CrossRef]
30. Malgorzata Gorska-Ciebiada, Malgorzata Saryusz-Wolska, Anna Borkowska, Maciej Ciebdad, and Jerzy Loba. "Serum levels of inflammatory markers in depressed elderly patients with diabetes and mild cognitive impairment." *PLoS ONE* 20 (2015): e0120433. [CrossRef] [PubMed]
31. Andrew Miller, Vladmir Maletic, and Charles Raison. "Inflammation and its discontents: The role of cytokine in the pathophysiology of major depression." *Biological Psychiatry* 65 (2009): 732–41. [CrossRef] [PubMed]
32. Jesse Stewart, Kevin Rand, Matthew Muldoon, and Thomas Kamarck. "A prospective evaluation of the directionality of the depression-inflammation relationship." *Brain, Behavior, and Immunity* 23 (2009): 936–44. [CrossRef] [PubMed]

33. Josep Puig, Gerard Blasco, Josep Daunis, Xavier Molina, Gemma Xifra, Wilfredo Ricart, Salvador Pedraza, Fernando Fernandez-Aranda, and Jose Fernandez-Real. "Hypothalamic damage is associated with inflammatory markers and worse cognitive performance in obese subjects." *The Journal of Clinical Endocrinology & Metabolism* 100 (2015): E276–81. [CrossRef] [PubMed]
34. Margarete Wichmann, Karen Cruickshanks, Cynthia Carlsson, Rick Chappell, Mary Fischer, Barbara Klein, Ronald Klein, Michael Tsai, and Carla Schubert. "Long-term systemic inflammation and cognitive impairment in a population-based cohort." *Journal of the American Geriatrics Society* 62 (2014): 1683–91. [CrossRef] [PubMed]
35. Andrew Steptoe, Mark Hamer, and Yoichi Chida. "The effects of acute-psychological stress on circulating inflammatory factors in humans: A review and meta-analysis." *Brain, Behavior, and Immunity* 21 (2007): 901–12. [CrossRef] [PubMed]
36. J. McAfoose, and B. T. Baune. "Evidence for a cytokine model of cognitive function." *Neuroscience & Biobehavioral Reviews* 33 (2009): 355–66. [CrossRef] [PubMed]
37. Duck-Hee Kang, Marti Rice, Na-Jin Park, Anne Turner-Henson, and Charles Downs. "Stress and inflammation: A biobehavioral approach for nursing research." *Western Journal of Nursing Research* 32 (2010): 730–60. [CrossRef] [PubMed]
38. Lisa Boss, Duck-Hee Kang, Marianne Marcus, and Nancy Bergstrom. "Endogenous sex hormones and cognitive function in older adults: A systematic review." *Western Journal of Nursing Research* 36 (2013): 388–426. [CrossRef] [PubMed]
39. Lisa Boss, Duck-Hee Kang, Nancy Bergstrom, and J. Leigh Leasure. "Psychosocial correlates to cognitive function in the elderly: A biobehavioral approach." *International Journal of Nursing* 2 (2015): 48–55. [CrossRef]
40. Meals on Wheels Association of America. Available online: www.mowaa.org (accessed on 10 May 2014).
41. Maureen Brady Moran. "Challenges in the Meals on Wheels program." *Journal of the American Dietetic Association* 104 (2004): 1219–21. [CrossRef] [PubMed]
42. George Alexopoulos. "Depression in the elderly." *Lancet* 365 (2005): 1961–70. [CrossRef]
43. Tami Saito, Ichiro Kai, and Ayako Takizawa. "Effects of a program to prevent social isolation on loneliness, depression, and subjective well-being of older adults: A randomized trail among older migrants in Japan." *Archives of Gerontology and Geriatrics* 55 (2012): 539–47. [CrossRef] [PubMed]
44. Sheldon Cohen, Tom Kamarck, and Robin Mermelstein. "A global measure of perceived stress." *Journal of Health and Social Behavior* 24 (1983): 386–96. [CrossRef]
45. Javald Sheikh, and Jerome Yesavage. "Geriatric Depression Scale (GDS): recent evidence and development of a shorter version." *Clinical Gerontologist* 5 (1986): 165–73.
46. Dan Russell, Letitia Peplau, and Carolyn Cutrona. "The revised UCLA Loneliness Scale: Concurrent and discriminant validity evidence." *Journal of Personality and Social Psychology* 39 (1980): 472–80. [CrossRef] [PubMed]
47. Donald Royall, Jeffrey Cordes, and Marsha Polk. "CLOX: An executive clock drawing task." *Journal of Neurology, Neurosurgery & Psychiatry* 64 (1998): 588–94. [CrossRef]
48. Salimetrics, LLC., State Park, PA, USA.
49. Hayden Bosworth, Kwang-Soo Park, Douglas McQuoid, Judith Hays, and David Steffens. "The impact of religious practice and religious coping on geriatric depression." *International Journal of Geriatric Psychiatry* 18 (2003): 905–14. [CrossRef] [PubMed]
50. John Cacioppo, and Louise Hawkley. "Perceived social isolation and cognition." *Trends in Cognitive Sciences* 13 (2009): 447–54. [CrossRef] [PubMed]
51. J. D. Weaver, M. H. Huang, M. Albert, T. Harris, J. W. Rowe, and Teresa Seeman. "Interleukin-6 and risk of cognitive decline: MacArthur studies of successful aging." *Neurology* 59 (2002): 371–78. [CrossRef] [PubMed]
52. K. Yaffe, K. Lindquist, B. Penninx, E. Simonsick, M. Pahor, and S. Kritchevsky. "Inflammatory markers and cognition in well-functionin African-American and white elders." *Neurology* 61 (2003): 76–80. [CrossRef] [PubMed]
53. Mats Lekander, Jan von Esson, Marianne Schultzberg, Anna Andreasson, Anita Garlind, Lars-Olof Hansson, and Lars-Goran Nilsson. "Cytokines and memory across the mature life span of women." *Scandinavian Journal of Psychology* 52 (2011): 229–35. [CrossRef] [PubMed]
54. R. Wilson, J. Schneider, P. Boyle, S. Arnold, Y. Tang, and D. Bennett. "Chronic distress and incidence of mild cognitive impairment." *Neurology* 68 (2007): 2085–92. [CrossRef] [PubMed]

55. Y. Leng, N. Wainwright, S. Hayat, B. Stephan, F. Matthews, R. Luben, P. Surtees, and C. Brayne. "The association between social stress and global cognitive function in a population-based study: The European Prospective Investigation into Cancer (EPIC)-Norfolk study." *Psychological Medicine* 43 (2013): 655–66. [CrossRef] [PubMed]
56. Indrag Lampe, Margriet Sitskoorn, and Thea Heeren. "Effects of recurrent major depressive disorder on behavior and cognitive function in female depressed patients." *Psychiatry Research* 125 (2004): 73–79. [CrossRef] [PubMed]
57. Kim Hinkelmann, Steffen Moritz, Johannes Botzenhardt, Kirsten Riedesel, Klaus Wiedemann, Michael Kellner, and Christian Otte. "Cognitive impairment in major depression: Association with salivary cortisol." *Biological Psychiatry* 66 (2009): 879–85. [CrossRef] [PubMed]
58. Reijo Tilvis, Mervi Kahonen-Vare, Juha Jolkkonen, Jaakko Valvanne, Kaisu Pitkala, and Timo Strandberg. "Predictors of decline and mortality of aged people over a 10-year period." *Journals of Gerontology Series A: Biological Sciences* 59 (2004): 268–74. [CrossRef]
59. Robert Wilson, Kristin Krueger, Steven Arnold, Julie Schneider, Jeremiah Kelly, Lisa Barnes, Yuxiao Tang, and David Bennett. "Loneliness and risk of Alzheimer's disease." *Archives of General Psychiatry* 64 (2007): 234–40. [CrossRef] [PubMed]
60. Ronald Glaser, and Janice Kiecolt-Glaser. "Stress-induced immune dysfunction: Implications for health." *Nature Reviews Immunology* 5 (2005): 243–51. [CrossRef] [PubMed]
61. Jennifer Piazza, David Almeida, Natalia Dmitrieva, and Laura Klein. "Frontiers in the use of biomarkers of health in research on stress and aging." *Journals of Gerontology. Series B: Psychological Sciences* 65 (2010): 513–25. [CrossRef] [PubMed]
62. Phillip Gorelick. "Role of inflammation in cognitive impairment: Results of observational epidemiological studies and clinical trials." *Annals of the New York Academy of Sciences* 1207 (2010): 155–62. [CrossRef] [PubMed]
63. Rebecca Rueggeberg, Carsten Wrosch, Gregory Miller, and Thomas McDade. "Associations between health-relate self-protection, diurnal cortisol, and C-reactive protein in lonely older adults." *Psychosomatic Medicine* 74 (2012): 937–44. [CrossRef] [PubMed]
64. James Noble, Jennifer Manly, Nicole Schupf, Ming Xing Tang, Richard Mayeux, and Jose Luchsinger. "Association of C-reactive protein with cognitive impairment." *Archives of Neurology* 67 (2010): 87–92. [CrossRef] [PubMed]