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Inflammation and Coagulation as Mediators in the Relationships between Religious Attendance and Functional Limitations in Older Adults

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Abstract

Objective—To examine inflammation and coagulation, which are positively linked to disability and inversely linked to increased religious attendance, as mediators in the cross-sectional relationships between religious attendance and functional status.

Methods—Frequency of attendance and limitations in basic activities of daily living (ADLs), instrumental activities (IADLs) and mobility were assessed in 1,423 elders.

Results—More frequent attendance was associated with fewer ADL, IADL, and mobility limitations, and with lower levels of inflammation and coagulation including interleukin-6, soluble vascular cell adhesion molecule, and D-dimer. Inflammation and coagulation partially mediated the associations between attendance and function. Eight percent of the effect of attendance on

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ADL (p=0.014), 5% of the effect on IADL (p=0.003), and 8% of the effect on mobility (p=0.001) limitations was due to inflammation and coagulation.

Discussion—Relationships between attendance and function may be due in part to lower levels of inflammation and coagulation among elders who attend services.

Keywords

Religion; aging; functional status; inflammation; coagulation

Although an impressive body of original research links religious participation to better health and function as well as decreased mortality (Koenig, McCullough, & Larson, 2001; Levin & Chatters, 1998; Powell, Shahabi, & Thoresen, 2003), the biological mechanisms underlying these associations have not been identified. Longitudinal studies have reported that religious attendance, in particular, decreases the risk of mortality and plays a preventive role for both physical and psychological health outcomes among older adults (Gillum, King, Obisesan, & Koenig, 2008; Idler & Kasl, 1997b; Koenig et al., 1999; Law & Sbarra, 2009; Park et al., 2008; Strawbridge, Cohen, & Shema, 2000). Recent longitudinal research utilizing rigorous statistical techniques suggests that religious attendance may offer protection against functional decline among older adults, even when controlling for health and social variables as well as initial functional status (Hybels, Blazer, George, & Koenig, 2012).

Decreased functional abilities and functional decline have significant public health implications for an aging population. Over 40% of older adults report one or more limitations in performing daily activities (Federal Interagency Forum on Aging Related Statistics, 2010). Difficulties performing instrumental activities of daily living (IADLs) such as shopping or handling medications are more prevalent than limitations in basic ADLs such as bathing, but as many as 25% of older adults have difficulty with at least one of the basic activities. Women report higher levels of functional impairment than men, and these limitations increase with age (Federal Interagency Forum on Aging Related Statistics, 2010). Decreased function can lead to loss of independence or placement in a residential care facility.

The association between religious attendance and functional status has been well-documented. Among older adults, attendance at religious services is associated in cross-sectional studies with fewer functional limitations (Idler & Kasl, 1997a) and longitudinally predicts less functional decline (Benjamins, 2004; Idler & Kasl, 1997b; Park et al., 2008). While these relationships between religious attendance and functional status are well-established, biological mechanisms underlying these relationships have not been identified.

This study, like other research tracing pathways from social factors to health outcomes, rests loosely on the stress process model. The stress process model is a stage model that includes categories of variables representing increasingly proximate causes of health outcomes (Pearlin, Lieberman, Menaghan, & Mullan, 1981). The most distal predictors are basic indicators of social location (e.g., age, gender, socioeconomic status). The next stage of the model is stressors, which are conceptualized as both outcomes of social location and

predictors of health. The third, most proximal set of predictors of health consists of social resources (or deficits) that are hypothesized to affect health directly, but to also mediate the effects of stress and, perhaps, social location on health. In essence, the stress process model was developed to trace the pathways by which social location and stress affect health. Over the past three decades, the stress process model has been refined (e.g., with increasingly comprehensive indicators of stress) and expanded (e.g., with the inclusion of mediators that were not part of the original model).

One extension of the stress process model has been to apply its logic to understanding the pathways by which social resources protect health (as opposed to the pathways by which stress puts health at risk). This study is in line with that logic – our goal is to identify mediators of the association between religious attendance and functional status. Another way that the stress process model has been expanded is through the introduction of biological mediators that represent pathways by which stressors exert harmful effects on health. Biological mediators frequently examined as possible pathways between stress and poor health include increased cortisol (the “stress hormone”), lowered immune function, and increased inflammation (Henry, 1992; Stowell, Robles, & Kane, 2012). Similarly, biological processes may mediate associations between social resources and health. Previous research, for example, has examined specific biomarkers as mediators of the associations of social support with health (e.g., Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002) and a sense of control or mastery (Roepke, Mausbach, & Grant, 2008; Wiedenfeld et al., 1990).

The theoretical hypothesis underlying this research is that one of the pathways by which social resources protect health is through low levels of inflammation and similar measures of physiological dysregulation. That is, that religious participation (a social resource) exerts its influence on functional status at least in part by altering human biology through physiological processes such as inflammation and coagulation. Although empirical findings are not totally consistent, previous work supports this hypothesis. Inflammation, for example, has been shown to be a partial mediator in the longitudinal relationship between frequency of attendance at religious services and mortality in a nationally representative cohort of adults aged 40 years and older (Gillum et al., 2008).

Inflammation and coagulation are individual host defense pathways which are often intersecting and mutually activating, and interface with the vascular endothelium (Cohen, Harris, & Pieper, 2003; Huffman et al., 2011; Petaja, 2011). Markers of chronic inflammation such as interleukin-6 (IL-6) and C-reactive protein, markers of endothelial activation promoted by inflammation such as concentrations of soluble vascular cell adhesion molecule (s-VCAM), and the coagulation marker D-dimer have been linked in cross-sectional studies with frailty in older adults (Brinkley et al., 2009; Cohen, Pieper, Harris, Rao, & Currie, 1997; Huffman et al., 2011; Kuo, Bean, Yen, & Leveille, 2006; Pieper, Rao, Currie, Harris, & Cohen, 2000). Although some studies have not found a longitudinal association (Huffman et al., 2011; McDermott et al., 2006; Reuben et al., 2002), other studies report that higher levels of inflammatory markers and coagulation are associated with a higher risk of functional decline (Cohen et al., 2003; Ferrucci et al., 1999; Ferrucci et al., 2002) and mortality (Cohen et al., 2003; Huffman et al., 2011).

Research to date has focused on the negative implications of physiological dysregulation on muscle strength and power, which in turn, increase functional impairment (e.g., Cesari et al., 2004; Ferrucci et al., 1999). Although more precise depiction of the specific processes by which suboptimal immune function and inflammation affect physical functioning is lacking, there is apparent consensus that these processes reflect a general increase in frailty rather than the consequences of specific diseases (Cesari et al., 2004; Ferrucci et al., 1999; Fried, Ferrucci, Darer, Williamson, & Anderson, 2004).

Why might religious attendance affect biological processes? It is long-established that humans respond to external conditions in a myriad of ways at social, psychological, and biological levels (Cohen, Kessler, & Underwood, 1995; Daruna, 2012). At the biological level, cardiovascular, neuroendocrine, parasympathetic and immune systems have been repeatedly demonstrated to react to external stimuli. Noxious stimuli generate biological adaptations, such as the fight-or-flight syndrome, that are beneficial in the short-run. With prolonged exposure to noxious stimuli, however, these biological adaptations take a physical and emotional toll on the organism by depleting resources and interfering with normal biological homeostasis. The effects of pleasant external stimuli on biological processes are less clear. Short-term experimental studies quite consistently indicate that pleasant experiences are associated with normal physiological responses (e.g., normal blood pressure and heart rate, immune function within the normal range) and positive emotions (e.g., Blood & Zatorre, 2001). But studies of the effects of long-term exposure to pleasant stimuli on biological processes are lacking. This is in contrast to numerous studies of the long-term effects of stress and other noxious stimuli on biological measures. This study does not shed light on the effects of long-term exposure to social resources on biomarkers. It does, however, examine a stimulus (religious service attendance) that has more relevance to everyday life than listening to enjoyable music or viewing pleasant pictures.

Although research in this area is minimal, measures of inflammation have been linked to religious participation. Religious attendance is inversely related to levels of IL-6 in cross-sectional studies (King, Mainous, Steyer, & Pearson, 2001; King, Mainous, & Pearson, 2002; Koenig et al., 1997). Longitudinally, using data from the Iowa Established Populations for Epidemiologic Studies of the Elderly (EPESE), investigators found that attending religious services more than once weekly predicted a lower risk of 12-year mortality, and that IL-6 partially mediated the prospective relationship between religious attendance and mortality (Lutgendorf, Russell, Ullrich, Harris, & Wallace, 2004).

In summary, religious involvement has been associated with aspects of human biology, especially basic physiologic processes that protect health and function and improve survival. It is not known whether pathways such as inflammation or coagulation play a mediating role in the relationship between religious involvement and functional status. Assessing these mediating roles even in cross-sectional data could assist in identifying potential biological pathways between religion and function and guide future research.

We recognize that variables such as social support, depressive symptoms, and health status may also be mediators in the associations between religious attendance and functional status. Persons who attend services, for example, may both give and receive social support from

this participation as well as from social ties outside the congregation. Similarly, studies have shown that depressive symptoms are associated with functional decline (Penninx et al., 1998), can be associated with religious attendance (Braam et al., 2004; Law & Sbarra, 2009), and are related to inflammatory processes (Dentino et al., 1999). Health status may also be related to attendance, inflammation and coagulation, and functional status. Inflammation and coagulation are pre-clinical measures of disease risk. We cannot determine whether increased levels of inflammation and coagulation precede or are a consequence of chronic disease.

The purpose of this study was to quantify the mediating effect of inflammation and coagulation in the cross-sectional relationships between religious attendance and functional limitations in older adults when demographic, health, and social variables are controlled. We hypothesized that measures of inflammation and coagulation would partially mediate the observed relationships between religious attendance and functional status, controlling for demographic, health, and social variables (age, race, sex, health conditions, self-rated health, cognitive status, depressive symptoms, marital status, education, smoking status, alcohol use, and perceived social support) known to be associated with both religious participation and functional status (Hybels et al., 2012).

A note on causality: many experimental studies examining the effects of various stimuli on biological variables and emotions clearly assume that their results meet the criteria needed for causal inference – and probably do. The same claims cannot be made for observational studies. The results reported in this paper are based on cross-sectional observational data. Consequently, they should be viewed as associations which may (or may not) support causal theories, but not as evidence of causal processes.

METHODS

Sample Description

The data derive from the Duke EPESE, a longitudinal study of community-dwelling older adults (Blazer, Burchett, Service, & George, 1991; Cornoni-Huntley et al., 1990). A total of 4,162 adults age 65+ were enrolled at baseline and followed for up to ten years. Blacks were oversampled and constituted 54% of the baseline sample. In-person follow-ups were conducted at three, six, and ten years post baseline. Biomarker data were collected at the six year follow-up only, making it difficult to establish whether changes in inflammation and coagulation resulted from or preceded religious attendance. Because our sample experienced significant attrition between the six and ten year follow-up, we examined the cross-sectional relationships among religious attendance, functional status and the biomarkers at the six-year follow-up. Participants provided written consent and the study protocol was reviewed and approved by the Duke Institutional Review Board.

Measures

Religious Attendance was measured by asking about frequency of attendance at services. Responses were coded as follows: 1=Never/almost never; 2=Once or twice a year; 3=Every

few months; 4=Once or twice a month; 5=Once a week; and 6=More than once a week. Attendance was treated as a continuous variable.

Physical function was assessed across three domains through self-report. Basic ADL tasks were assessed as done by Katz et al. by asking if the participant needed help with bathing, dressing, eating, toileting and getting from the bed to a chair (scale range 0–5) (Katz, Downs, Cash, & Grotz, 1970). IADL limitations identified help with driving a car or traveling alone, shopping for groceries/clothes alone, preparing meals, doing own housework and handling money (scale range 0–5) (Fillenbaum, 1988). Mobility was measured as done by Rosow and Breslau as ability to do heavy work, walk up and down the stairs and walk one half mile (scale range 0–3) (Rosow & Breslau, 1966). For each of the three scales, higher values indicated more limitations.

Blood samples were collected to obtain hematology and blood chemistry lab values as well as inflammatory and coagulation markers. Blood was drawn from all participants who were able to provide consent and agreed to the blood draw. Overall, 67% of those interviewed had a blood sample available (Huffman et al., 2011). Those for whom blood draws were not available tended to be older and more impaired compared to those who agreed to the blood draw (Pieper et al., 2000). The collection, handling, storage, and analysis protocol have been previously described (Cohen et al., 1997; Huffman et al., 2011; Koenig et al., 1997; Pieper et al., 2000). In summary, blood was collected in ethylenediaminetetraacetic acid-containing Vacutainer tubes, placed on ice and taken to the laboratory where it was centrifuged and the plasma frozen at −70 degrees Centigrade in 0.5-mL aliquots. The analyses in this paper focus on the mediating effects of three biomarkers examined in the Duke sample: IL6, D-dimer and s-VCAM (C-reactive protein was not measured in the Duke EPESE). These three available biomarkers are independent measures of different aspects of the inflammatory and coagulation cascades, i.e., inflammation (IL6), coagulation (D-dimer), and vascular activation (s-VCAM) (Cohen et al., 2003; Huffman et al., 2011). Concentrations of IL6, D-dimer and s-VCAM were measured by enzyme-linked immunoassays (Quantikine, R&D Systems, Minneapolis, MN; Dimertest Tripwell EIA Kit, American Diagnostical, Greenwich, CT; and R&D Systems, Minneapolis, MN, respectively). The distributions of the values were all right skewed and log transformed values were employed in these analyses. Lower inflammatory and coagulation marker values indicate better health. We were interested in the mediating effects of the three variables as a group. Descriptive statistics showed the three values to be only weakly related (Cronbach coefficient alpha=0.38). The direct effects of each of the three measures on functional status have been previously reported (see Huffman et al., 2011).

Sociodemographic variables included age as a continuous variable, sex (male=1, female=0), marital status (Not married=1, Married=0), and years of education as a continuous variable. Participants were coded 1 if race was White or other and 0 if race was Black. Less than 1% of the participants were coded as Other.

Cognitive Status was measured using the Short Portable Mental Status Questionnaire (SPMSQ) (Pfeiffer, 1975). Few participants had impairment in cognition. We used a

dichotomous variable (1=3+ errors, 0=<3), with the number of errors adjusted for race and education as specified for the scale.

A variable measuring *Health Status* recorded the presence of five conditions (heart problems, hypertension, diabetes, stroke, and cancer) (Fillenbaum, Leiss, Pieper, & Cohen, 1998), dichotomized with the top 1/3 of the participants with the most conditions coded 1 and the others coded 0. Self-rated health was coded 1=fair or poor and 0=excellent or good. A modified version of the Center for Epidemiologic Studies-Depression scale (CES-D), with each of the 20 symptoms coded Y=1/N=0 if experienced the previous week, was used to measure depressive symptoms (Blazer et al., 1991; Radloff, 1977). Smoking status was coded 1 if the participant was a current smoker and 0 if not. Alcohol use was coded 1 if the participant drank on average 2 or more drinks of beer, wine, and or liquor per week and 0 if less than 2 drinks of alcohol per week.

Social variables included questions concerning perceived social support (how much do participants feel they can count on or talk to friends and family – range 1 to 5 with higher values indicating more support).

Statistical Analysis

We used linear regression to estimate the cross-sectional associations between religious attendance and functional status and the mediating effects of IL6, s-VCAM, and D-dimer, controlling for demographic, health, and social variables. Attendance may be directly associated with function, but also may indirectly be associated by affecting the biomarkers which then affect function. The total effect is the sum of these direct and indirect effects. Each domain of function (ADL, IADL and mobility) was estimated separately.

The indirect associations were estimated using methods developed by Preacher and Hayes (Preacher & Hayes, 2008). These methods offer distinct advantages by allowing multiple mediators to be assessed as a group within one model. All analyses were performed using SAS software, Version 9.3 (SAS Institute Inc, Cary, NC).

Data for religious participation, functional limitations and biomarkers as well as the covariates were available for 1,423 participants.

RESULTS

Table 1 shows the characteristics of the sample. The sample had on average few limitations in ADL tasks, IADL tasks and mobility. The sample was predominantly Black and female, had less than a high school education, had good cognitive functioning, and had some chronic health conditions. The sample was older than when initially enrolled, and averaged 77.8 years of age. The proportion of participants who were current smokers or consumed 2 or more alcoholic drinks per week on average was low. A total of 31 of the 1,423 participants (2%) were taking anticoagulants.

The sample was predominantly Christian, with only 24 of the 1,423 participants (2%) responding either ‘None’, ‘Jewish’, or ‘Non-Christian’ to a question asking about religious preference. A total of 97% of the participants reported their preference as ‘Protestant.’

Religious attendance was reported as follows: 16% never/almost never, 5% once or twice a year, 5% every few months, 16% once or twice a month, 37% once a week, and 21% more than once a week.

As shown in Table 2, more frequent attendance was correlated with fewer IADL limitations ($r= -0.32$; $p<0.0001$), fewer ADL limitations ($r= -0.23$; $p<0.0001$), and fewer mobility limitations ($r= -0.26$; $p<0.0001$) and with lower levels of (log)IL6 ($r= -0.11$; $p<0.0001$), (log)s-VCAM ($r= -0.12$; $p<0.0001$) and (log)D-dimer ($r= -0.10$; $p=0.0002$). More frequent attendance was also associated with younger age, more years of education, being married, and having higher perceived social support. Whites attended less frequently than Blacks. Less frequent attendance was also associated with mild/moderate cognitive impairment, more chronic conditions, fair or poor self-rated health, more depressive symptoms, smoking and current alcohol use. Overall, older adults who attended services were generally in better health than those who did not attend services. Higher levels of inflammation and coagulation were in general associated with more functional limitations, older age, fewer years of education, and poorer health.

Table 3 shows the results of four hierarchical models for each domain of function. For all three outcomes, more frequent attendance was associated with fewer functional limitations in uncontrolled analyses (Model 1), controlling for age, race, and sex (Model 2), and controlling for age, race, sex, education, marital status, cognitive status, chronic conditions, self-rated health, smoking status, alcohol use, depression score, and perceived social support (Model 3). For ADL limitations, the association between attendance and ADL function remained statistically significant when the biomarkers were included. As shown by the Model 4 indirect effects, controlling for the demographic, health, and social variables, 8% (−0.007/−0.091) of the effect of attendance on ADL function was mediated through inflammation and coagulation ($p=0.0136$). Similar patterns were observed for IADL limitations. When the demographic, health, and social variables were controlled, 5% (−0.011/−0,213) of the effect of attendance on IADL function was through inflammation and coagulation ($p=0.0030$). The association between frequency of attendance and limitations in mobility remained statistically significant when the three biomarkers were included. When the demographic, health, and social variables were controlled, 8% (−0.010/−0.125) of the relationship between religious attendance and mobility status was through inflammation and coagulation ($p=0.0012$).

To confirm that the findings of significant mediation were not a function of specifying a linear outcome, we estimated the same series of models using a negative binomial distribution and obtained similar results.

Table 4 presents the results for the final models for each of the three domains of function using linear regression. Religious attendance was significantly associated with each of the three function domains in these controlled analyses. As expected from earlier analyses, higher levels of Il6 were associated with more limitations in ADL and IADL tasks, higher levels of s-VCAM were associated with more limitations in ADL and IADL tasks as well as mobility, and higher levels of D-dimer were associated with more limitations in IADL tasks and mobility in our analysis sample.

DISCUSSION

Despite decades of research reporting positive relationships between religion and health, possible biological mechanisms underlying these associations have not been identified. Our findings support the theoretical hypothesis that religion influences functional status in part through its effect on physiological processes, in particular, inflammation and coagulation. The finding that these processes were significant mediators in the relationships between attendance and functional status were consistent across all three domains of function. That is, religious participation may be associated with pre-clinical markers of disease risk such as inflammation and coagulation, and its effect on these processes may be one mechanism underlying the observed positive relationships between religion and functional status. While inflammation and coagulation account for only a small percentage of the overall effect of religious attendance, these effects are independent of demographic, health, and social variables, and may point to potential biological pathways.

Our cross-sectional findings that increased religious attendance was inversely related to fewer functional limitations are consistent with those of Idler and Kasl who reported that the proportion of older adults attending services was lower among those with more disability (Idler & Kasl, 1997a). Likewise, our findings that higher levels of inflammation and coagulation were associated with poorer physical function are consistent with other reports of these relationships (Brinkley et al., 2009; Cohen et al., 2003; Huffman et al., 2011; Kuo et al., 2006; Pieper et al., 2000).

These findings are preliminary and have limitations. The analyses are cross-sectional so we cannot establish temporality in these relationships. Religious attendance may either help prevent the development of disabilities by reducing inflammatory and coagulation markers (through helping older adults cope better with aging and reducing stress) or poor physical functioning or diseases that increase inflammation may prevent older adults from attending services. Future longitudinal work could help address these issues. The youngest participant in our sample was 71 years of age, so these findings primarily apply to older adults. We only controlled for selected chronic diseases and recognize there may be other diseases related to inflammation and coagulation, such as arthritis, that were not included in our analyses. Our sample was almost exclusively Christian, and other faiths were not sufficiently represented to allow comparisons across and between faith groups. We have no reason to expect that the results would be significantly different between faith groups. While we chose to focus on religious attendance, other measures such as spirituality or prayer may offer additional information.

While these data were taken from the third wave of a longitudinal study, the older age of our sample resulted in considerable attrition between this analysis wave and the next wave four years later, making it difficult to study longitudinal associations within these data. As an exploratory analysis, we examined the relationships longitudinally (attendance at year 3, mediating biomarkers at year 6, and functional status at year 10). The results supported our mediating hypothesis, but because of the small sample size we are not confident that the coefficients are stable and accurate.

To the best of our knowledge, however, this is the first study to examine inflammation and coagulation as mediators in the relationships between religious participation and functional status. Although there is increased acceptance by clinicians of the role religious participation may play in health and healing, these findings can potentially move the field of religion and health forward by quantifying the role of inflammation and coagulation and suggesting possible avenues of biological plausibility. Constructs of biology, psychology and religion/spirituality are thought to be connected through neurological, endocrine and immune pathways (Koenig & Cohen, 2002). Studies of these associations in later life, when declines in health and function are more prevalent and physiological changes are most likely to occur, can be especially informative. Future research could not only utilize longitudinal data, but explore the mechanism by which religious attendance may influence inflammation and coagulation. For instance, attendance may decrease the effects of stress and/or depression on the body or through other psychological or social mechanisms. Religious attendance may also provide opportunities for developing social ties that are distinctive from conventional social ties such as marital status and perceived social support (for a comparison of congregation-based and secular social ties, see Krause, 2006).

While religious attendance cannot be prescribed for older adults, these findings provide a window into biological mechanisms that could be an important part of treatment and clinical instruction for older adults for whom religious participation is important.

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Table 1

Characteristics of the Sample (n=1,423)

Sample Characteristic	
Mean # ADL limitations (SD)	0.27 (0.86)
Mean # mobility limitations (SD)	0.96 (1.14)
Mean # IADL limitations (SD)	0.77 (1.37)
Mean age (SD)	77.8 (5.3)
# White (%)	693 (48.7%)
# Male (%)	484 (34.0%)
Mean years of education (SD)	9.1 (4.0)
# Not married (%)	898 (63.1%)
# Mild / moderate cognitive impairment (%)	154 (10.8%)
# with more chronic conditions (%)	598 (42.0%)
# with fair/poor self-rated health (%)	558 (39.2%)
# Current smoker (%)	168 (11.8%)
# Report 2+ drinks per week (%)	127 (8.9%)
Mean level perceived social support (SD)	4.6 (0.8)
Mean CES-D score (SD) *	2.81 (3.49)
Median IL6 (IQR)	1.66 (0.95, 2.92)
Mean IL6 (SD) (log)	1.07 (0.64)
Median s-VCAM (IQR)	507.0 (411.9, 640.8)
Mean s-VCAM (SD) (log)	6.25 (0.49)
Median D-dimer (IQR)	195.0 (121.0, 323.0)
Mean D-dimer (SD) (log)	5.31 (0.77)

* Modified CES-D had a possible score of 0–20 symptoms

Table 2

Correlations among Religious Attendance, Measures of Inflammation and Coagulation and Functional Status as well as Covariates (n=1,423)

	Religious Attendance	IL6 (log)	s-VCAM (log)	D-dimer (log)	# ADL Limitations	# Mobility Limitations	# IADL Limitations
Religious Attendance	1.0000						
IL6 (log)	-0.1141 <0.0001	1.0000					
s-VCAM (log)	−0.1249 <0.0001	0.1380 <0.0001	1.0000				
D-dimer (log)	−0.0995 0.0002	0.2489 <0.0001	0.1278 <0.0001	1.0000			
#ADL Limitations	−0.2280 <0.0001	0.1568 <0.0001	0.1367 <0.0001	0.1607 <0.0001	1.0000		
# Mobility Limitations	−0.2646 <0.0001	0.1469 <0.0001	0.1731 <0.0001	0.2531 <0.0001	0.4801 <0.0001	1.0000	
#IADL Limitations	−0.3193 <0.0001	0.1651 <0.0001	0.1660 <0.0001	0.2169 <0.0001	0.6035 <0.0001	0.6319 <0.0001	1.0000
Age	−0.1161 <0.0001	0.1164 <0.0001	0.1306 <0.0001	0.2331 <0.0001	0.2283 <0.0001	0.3146 <0.0001	0.3318 <0.0001
White	−0.0643 0.0152	−0.0256 0.3344	0.0848 0.0014	−0.2408 <0.0001	−0.0879 0.0009	−0.1509 <0.0001	−0.1231 <0.0001
Male	−0.0407 0.1251	0.0077 0.7725	−0.0439 0.0978	−0.0459 0.0839	−0.0861 0.0011	−0.2062 <0.0001	−0.1322 <0.0001
Years of Education	0.1122 <0.0001	−0.1027 0.0001	−0.0743 0.0051	−0.1472 <0.0001	−0.1080 <0.0001	−0.1927 <0.0001	−0.1849 <0.0001
Not Married	−0.0738 0.0054	0.0448 0.0913	0.0911 0.0006	0.1589 <0.0001	0.1138 <0.0001	0.2439 <0.0001	0.1813 <0.0001
Mild/moderate Cognitive Impairment	−0.0569 0.0318	0.0405 0.1267	0.0661 0.0126	0.1125 <0.0001	0.1459 <0.0001	0.1271 <0.0001	0.1968 <0.0001
More Chronic Conditions	−0.1483 <0.0001	0.1093 <0.0001	0.0780 0.0032	−0.0089 0.7382	0.1189 <0.0001	0.2127 <0.0001	0.1595 <0.0001
Fair/Poor Self-Rated Health	−0.1219 <0.0001	0.0706 0.0077	0.0620 0.0194	0.1110 <0.0001	0.1638 <0.0001	0.3585 <0.0001	0.2249 <0.0001
Current Smoker	−0.1159 <0.0001	0.0840 0.0015	0.0234 0.3782	0.0458 0.0839	−0.0349 0.1885	−0.0182 0.4931	−0.0417 0.1162
Alcohol 2+ Times/week	−0.1530 <0.0001	−0.0248 0.3492	−0.0888 0.0008	−0.0783 0.0031	−0.0736 0.0054	−0.1474 <0.0001	−0.1054 <0.0001
Perceived Social Support	0.1153 <0.0001	−0.0420 0.1137	−0.0272 0.3054	−0.0348 0.1896	−0.1208 <0.0001	−0.0913 0.0006	−0.0502 0.0586
CES-D Score	−0.1369 <0.0001	0.0402 0.1293	0.0802 0.0025	0.0645 0.0150	0.2518 <0.0001	0.3375 <0.0001	0.2585 <0.0001

Table 3

Hierarchical Regression Models Showing the Cross-Sectional Associations between Attending Religious Services and Functional Status and the Mediating Effects of Measures of Inflammation and Coagulation (n=1,423)

	Estimate	ADL Standard Error	p-value		Estimate	IADL Standard Error	p-value		Estimate	Mobility Standard Error	p-value
Model 1				*Model 1*				*Model 1*			
Religious attendance	−0.115	0.013	<0.0001	Religious attendance	−0.260	0.020	<0.0001	Religious attendance	−0.178	0.017	<0.0001
(Model 1 is uncontrolled)											
Model 2				*Model 2*				*Model 2*			
Religious attendance	−0.108	0.013	<0.0001	Religious attendance	−0.243	0.019	<0.0001	Religious attendance	−0.170	0.016	<0.0001
(Model 2 controls for age, sex, and race)											
Model 3				*Model 3*				*Model 3*			
Religious attendance	−0.091	0.013	<0.0001	Religious attendance	−0.213	0.019	<0.0001	Religious attendance	−0.125	0.015	<0.0001
(Model 3 controls for the demographic, health, and social variables)											
Model 4				*Model 4*				*Model 4*			
Religious attendance				Religious attendance				Religious attendance			
Total	−0.091	0.013	<0.0001	*Total*	−0.213	0.019	<0.0001	*Total*	−0.125	0.015	<0.0001
Indirect	−0.007	0.003	0.0136	*Indirect*	−0.011	0.004	0.0030	*Indirect*	−0.010	0.003	0.0012
Direct	−0.084	0.013	<0.0001	*Direct*	−0.202	0.019	<0.0001	*Direct*	−0.115	0.015	<0.0001
(Model 4 controls for the demographic, health, and social variables and the three biomarkers and quantifies the indirect effects of attendance on function through the biomarkers controlling for the demographic, health, and social variables)											

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Table 4

Final Linear Regression Models showing the Cross-Sectional Associations between Attending Religious Services and Functional Status Controlling for Demographic, Health, and Social Variables, and Measures of Inflammation and Coagulation (n=1,423)

	Estimate	ADL Standard Error	p-value		Estimate	IADL Standard Error	p-value		Estimate	Mobility Standard Error	p-value
Intercept	−2.059	0.455	<0.0001	Intercept	−4.940	0.671	<0.0001	Intercept	−3.779	0.532	<0.0001
Religious attendance	−0.084	0.013	<0.0001	Religious attendance	−0.202	0.019	<0.0001	Religious attendance	−0.115	0.015	<0.0001
Age	0.022	0.004	<0.0001	Age	0.056	0.006	<0.0001	Age	0.040	0.005	<0.0001
Male	−0.058	0.052	0.2659	Male	−0.172	0.077	0.0263	Male	−0.279	0.061	<0.0001
White	−0.102	0.046	0.0272	White	−0.200	0.068	0.0034	White	−0.158	0.054	0.0035
Years Education	0.002	0.006	0.7961	Years Education	−0.019	0.009	0.0262	Years Education	−0.011	0.007	0.0930
Not Married	−0.011	0.051	0.8304	Not Married	0.033	0.075	0.6632	Not Married	0.126	0.060	0.0352
Mild/Moderate Cognitive Imp	0.225	0.068	0.0010	Mild/Moderate Cognitive Imp	0.553	0.101	<0.0001	Mild/Moderate Cognitive Imp	0.176	0.080	0.0278
More Chronic Conditions	0.089	0.044	0.0432	More Chronic Conditions	0.204	0.065	0.0016	More Chronic Conditions	0.267	0.051	<0.0001
Fair/Poor Self-Rated Health	0.085	0.047	0.0697	Fair/Poor Self-Rated Health	0.281	0.069	<0.0001	Fair/Poor Self-Rated Health	0.500	0.055	<0.0001
Smoker	−0.094	0.067	0.1620	Smoker	−0.137	0.099	0.1683	Smoker	−0.018	0.079	0.8230
Alcohol 2+ Times/Week	−0.135	0.078	0.0817	Alcohol 2+ Times/Week	−0.289	0.114	0.0117	Alcohol 2+ Times/Week	−0.275	0.091	0.0024
CES-D Score	0.038	0.007	<0.0001	CES-D Score	0.048	0.010	<0.0001	CES-D Score	0.050	0.008	<0.0001
Perceived Social Support	−0.030	0.026	0.2542	Perceived Social Support	0.108	0.039	0.0056	Perceived Social Support	0.031	0.031	0.3158
IL6 (log)	0.115	0.034	0.0008	IL6 (log)	0.132	0.051	0.0090	IL6 (log)	0.053	0.040	0.1908
s-VCAM (log)	0.100	0.044	0.0241	s-VCAM (log)	0.161	0.065	0.0140	s-VCAM (log)	0.142	0.052	0.0061
D-dimer (log)	0.048	0.030	0.1058	D-dimer (log)	0.101	0.044	0.0228	D-dimer (log)	0.147	0.035	<0.0001