

*Original Research Article***Salivary Alpha-Amylase and Cortisol Among Pentecostals on a Worship and Nonworship Day**CHRISTOPHER DANA LYNN,^{1*} JASON PARIS,² CHERYL ANNE FRYE,^{2,3,4,5} AND LAWRENCE M. SCHELL^{6,7}¹*Department of Anthropology, The University of Alabama, Tuscaloosa, Alabama*²*Department of Psychology, The University at Albany-SUNY, Albany, New York*³*Department of Biology, The University at Albany-SUNY, Albany, New York*⁴*Center for Neuroscience Research, The University at Albany-SUNY, Albany, New York*⁵*Center for Life Sciences Research, The University at Albany-SUNY, Albany, New York*⁶*Department of Anthropology, The University at Albany-SUNY, Albany, New York*⁷*Department of Epidemiology and Biostatistics, The University at Albany-SUNY, Albany, New York*

Objectives: This investigation used a biomarker of sympathetic nervous system activity novel to biocultural research to test the hypothesis that engaging in religious worship activities would reduce baseline stress levels on a non-worship day among Pentecostals.

Methods: As detailed in Lynn et al. (submitted for publication), stress was measured via salivary cortisol and α -amylase among 52 Apostolic Pentecostals in New York's mid-Hudson Valley. Saliva samples were collected at four predetermined times on consecutive Sundays and Mondays to establish diurnal profiles and compare days of worship and non-worship. These data were reanalyzed using separate analyses of covariance on α -amylase and cortisol to control for individual variation in Pentecostal behavior, effects of Sunday biomarkers on Monday, and other covariates.

Results: There was a significant decrease in cortisol and an increase in α -amylase on a non-worship day compared with a service day. Models including engagement in Pentecostal worship behavior explained 62% of the change in non-service day cortisol and 73% of the change in non-service day α -amylase.

Conclusions: Engagement in Pentecostal worship may be associated with reductions in circulatory cortisol and enhancements in α -amylase activity. *Am. J. Hum. Biol.* 22:819–822, 2010. © 2010 Wiley-Liss, Inc.

Pentecostalism has been called the most successful Christian movement of the 20th century (Cleary, 1997), with over 523 million Pentecostals or Charismatics worldwide (Barrett and Johnson, 2004), and is held to be an effective recourse for health-related problems (Chesnut, 2000). This study examined the effect of experiential worship on biomarkers of stress physiology by comparing salivary α -amylase (sAA) and cortisol on a day of service and non-service. We hypothesized that, due to the arousal of Pentecostal worship, both sAA and cortisol, proxies of sympathetic nervous system (SNS) activity (Nater and Rohleder, 2009) and hypothalamic–pituitary–adrenal (HPA) axis (Hellhammer et al., 2009), respectively, would be elevated on a day of service but reduced on a day of non-service. Further, engagement in Pentecostal worship behavior would predict the reduction in HPA/SNS activity observed on the non-service day.

The measurement of stress physiology as a proxy of health is useful because of the ubiquity of psychosocial stress in daily life and the global prevalence of stress-related diseases. This study draws on the model of stress as any “nonspecific demand” (Selye, 1984), which includes stress as positive (excitement), neutral (arousal), and negative (fight-or-flight). To accurately assess the physiological correlates of the stress system, it has been suggested that multiple measures over multiple systems should be assessed (Lovallo and Thomas, 2000). A simple, noninvasive means to measure stress physiology in relation to behavior is through the self-collection of saliva samples, which contain the hormone cortisol and enzyme α -amylase. Cortisol has been used extensively in similar studies of stress response (Hellhammer et al., 2009), whereas α -amylase has only recently been developed for this use

(Granger et al., 2007), and its relationship to SNS activity is not fully established (DeCaro, 2008; Nater and Rohleder, 2009; Rohleder and Nater, 2009). Cortisol and α -amylase cycle daily; thus, several samples throughout a day are generally used (Kirschbaum and Hellhammer, 2007; Rohleder and Nater, 2009).

This study uses cortisol as a well-known proxy of stress physiology to compare the activity of α -amylase. We compare the activity of these biomarkers on a day of religious worship and a day of non-worship and with regard to individual Pentecostal religiosity. We know of no other such study published that compares these biomarkers in a naturalistic setting.

METHODS

These analyses use data collected during a biocultural investigation of Pentecostal behavior and health conducted from 2006 to 2009 and outlined in Lynn et al. (submitted for publication). We, therefore, provide only a brief outline of the methods used here. All protocols were

Contract grant sponsor: National Science Foundation; Contract grant number: 0819190 (to C.D.L.); Contract grant sponsor: Society for the Scientific Study of Religion, SUNY Benevolent Association, University at Albany Graduate Studies and GSO (to C.D.L.); Contract grant numbers: MH0676980, RMH067698b (to J.P. and C.A.F.); Contract grant number: R24 MD001120 (to L.M.S.).

*Correspondence to: Christopher D. Lynn, Ph.D., Department of Anthropology, University of Alabama, Box 870210, Tuscaloosa, AL 35487. E-mail: cdlynn@ua.edu

Received 27 December 2009; Revision received 9 July 2010; Accepted 13 July 2010

DOI 10.1002/ajhb.21088

Published online 28 September 2010 in Wiley Online Library (wileyonlinelibrary.com).

TABLE 1. Characteristics of Pentecostal sample

Have attended at least some college	73.1%
Middle or high social status (top 2/3)	84.6%
Have at least one dependent child	48.1%
Have at least two people nearby to count on in time of need	94.2%
Get at least 7 h of sleep per night	57.7%
Low or moderate perceived stress (bottom 2/3)	67.3%
Elite or core church member	57.7%
High or moderate religiosity (top 2/3)	63.5%
High or moderate faith maturity (top 2/3)	63.5%
Have spoken in tongues	73.1%

reviewed and approved by the University at Albany Institutional Review Board.

Data retained for analyses were from 52 male (48%) and female (52%) participants. Age range was 18–69 ($x = 33.3$, $SD = 11.16$). Thirty-two were in committed relationships, and 20 were single. Participants were volunteers from two Apostolic Pentecostal churches in Poughkeepsie (56%) and Kingston (44%), NY. One church was ethnically diverse, and the other primarily Jamaican immigrants. Despite this difference, both churches expressly projected themselves as Apostolic and played down any cultural distinctions.

Sociodemographic information included relationship status, sex, social support, social status (following Singh-Manoux et al., 2003), education, age, and sleep cycle. Questionnaire data included the Perceived Stress Scale (Cohen and Williamson, 1988), which was used to assess stress appraisal; Faith Maturity Scale (Benson et al., 1993); Religiosity Measures Questionnaire (Rohrbaugh and Jessor, 1975), which included an item quantifying frequency of service attendance; and a glossolalia (“speaking in tongues”) questionnaire (described in Lynn et al., submitted for publication) to control for the general effects that the Pentecostal religiosity and faith would have on daily stress. Glossolalia is a characteristic behavior of Pentecostals, consisting of nonsensical utterances emitted in conjunction with a mild dissociative state. Being thus “filled with the Holy Ghost” is interpreted by Pentecostal brethren as divine speech and validation by God that one has truly accepted Jesus Christ as savior (Goodman, 1972). Instantiations range from those deemed “ecstatic,” involving intense public trance states, to those that are private, subtle, and only perceptible to the trained observer (Grady and Loewenthal, 1997).

Saliva sampling was conducted using commercially available collection tubes and synthetic swabs (Salimetrics LLC, State College, PA) on a Sunday as the day of worship and Monday as the non-service day at 10 a.m., 2:30 p.m., 6 p.m., and 10 p.m. Samples were transported to University of Albany and frozen (-30°) until assayed. Assays were conducted using commercially available kits using the protocols outlined in those kits (Salimetrics). Intra- and interassay coefficients were within normal range (Lynn et al., submitted for publication).

Statistical analysis

Statistical analyses were conducted using SPSS Statistics Version 17.0 for Windows (SPSS, Inc., Chicago, IL) and considered significant if $P = 0.05$. Descriptives and frequencies are in Lynn et al. (submitted for publication). Alpha-amylase values were normally distributed, but cortisol concentrations were not and were, therefore, log-

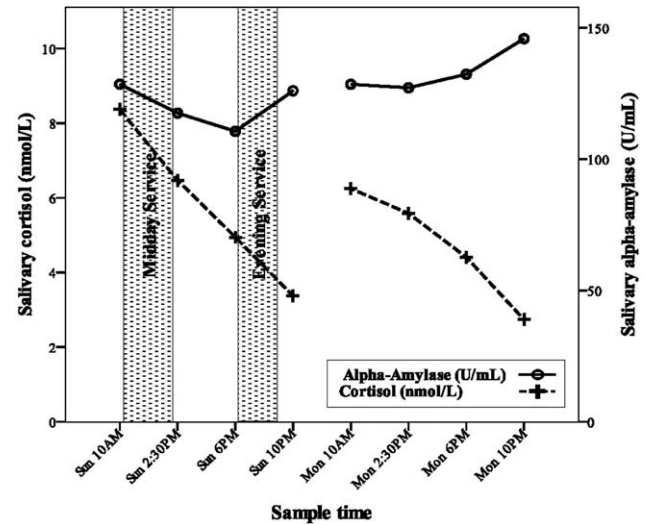


Fig. 1. Diurnal salivary alpha-amylase and cortisol of Pentecostals across a service and non-service day.

transformed. Analyses of covariance (ANCOVAs) were conducted on diurnal means of both biomarkers to evaluate the effects of Sunday diurnal values and other covariates on Monday measures. Model covariates were determined by backward elimination.

RESULTS

Descriptives are in Table 1 and additional details in Lynn et al. (submitted for publication). This study predicted that Pentecostal behavior would influence a reduction in stress on a non-service day (Monday) relative to a service day (Sunday). As Figure 1 illustrates, there seems to be a reduction in cortisol but an increase in sAA.

ANCOVA was conducted on the diurnal mean of Monday cortisol (Table 2). This statistical method was used because Monday is being compared with, but is not independent of, Sunday cortisol. Other covariates included in the model were social status, social support, the participant's church, quality of sleep, religiosity (Religiosity Measures Questionnaire), faith maturity (Faith Maturity Scale), and Pentecostal behavior (glossolalia). This model significantly ($P < 0.001$) explained 62% of the variance in Monday diurnal cortisol. In particular, general Christian religiosity, social status, quality of sleep, church, and social support were significant predictors of Monday cortisol.

The ANCOVA model for sAA (Table 3) included, in addition to the Sunday diurnal sAA mean, age, education, church attended, hours of sleep, religiosity, faith maturity, and glossolalia. This model significantly ($P < 0.001$) explained 73% of the variability in the pooled mean of Monday diurnal sAA. The only significant predictors besides Sunday values were age and glossolalia (Pentecostal behavior).

DISCUSSION

This study sought to measure the influence of Pentecostal worship on baseline autonomic and SNS activity through measures of stress physiology. It was hypothesized that worship would stimulate HPA and SNS arousal

TABLE 2. Influences on Monday (non-service day) salivary cortisol using ANCOVA

	df	Mean square	F	Significance
Corrected model	8	0.44	8.63	0.00
Intercept	1	0.02	0.44	0.51
Cortisol _{log10} Sunday mean	1	2.73	53.74	0.00
Social status	1	0.35	6.83	0.01
Social support	1	0.21	4.08	0.05
Church	1	0.22	4.33	0.04
Quality of sleep	1	0.24	4.64	0.04
Religiosity	1	0.36	7.15	0.01
Faith maturity	1	0.17	3.33	0.08
Glossolalia	1	0.17	3.39	0.07

$r^2 = 0.62$ (adjusted $r^2 = 0.55$).

on Sunday relative to Monday. Cortisol measures indicate that lower levels occur across the Monday diurnal cycle, but this is more attributable to general Christian religiosity, social status, sleep quality, church attended, and social support than specifically to Pentecostal behavior. However, the covariate selection process suggested that Pentecostal behavior is important and merits further examination. Alternatively, sAA yielded a diurnal pattern higher on Monday rather than lower, and this was attributable in the model only to Pentecostal behavior and age. This contrast suggests that further research is required to better understand the influence of religious behavior on the physiology of human stress and adaptation, yet it supports recent data indicating nonoverlapping activity in the HPA axis and SNS.

This study included cortisol as a standard noninvasive field method for assessing HPA axis over an extended period. Additionally, we used α -amylase as a proxy of SNS activity because multiple methods are suggested to better assess stress physiology (Lovallo and Thomas, 2000). This biomarker combination has been used in a handful of recent studies (e.g., Gordis et al., 2006, 2008; Granger et al., 2006; Kivlighan and Granger, 2006; Strahler et al., 2010; Wolf et al., 2008) but not previously in biocultural research. On the basis of the associations of salivary cortisol and sAA with the HPA axis and SNS, respectively, it was expected that, although both would display typical diurnal patterns, elevations would indicate the temporal proximity of stressful experiences. Elevations in sAA would indicate more recent stressful experiences because of the quicker reactivity of the SNS system and elevations in cortisol indicative of earlier experiences because of the slower reactivity of the HPA axis (Chrousos and Gold, 1992). This is the pattern observed in laboratory studies using the Trier Social Stress test (Gordis et al., 2006; Stroud et al., 2006). This study took place in a naturalistic setting with no induced stress by which to evaluate this inference. However, the elevation of sAA at 10 p.m. on both Sunday and Monday and 6 p.m. on Sunday may be indicative of known potential stressors experienced immediately before the sample was taken. Sunday 6 p.m. is approximately when the evening evangelical service begins at one of the churches, whereas 10 p.m. may be relatively late for many participants and receiving a call or text to take a saliva sample possibly an aggravation.

There is a debate as to the specificity of the HPA axis and SNS as stress systems, with essentially three different positions being taken (Brandstädter et al., 1991). One is that the HPA axis is responsive to perceived "threats," whereas the SNS could be better termed an "arousal" sys-

TABLE 3. Influences on Monday (non-service day) salivary alpha-amylase using ANCOVA

	df	Mean square	F	Significance
Corrected model	8	27,608	14.3	0.00
Intercept	1	852	0.4	0.51
sAA Sunday mean	1	170,944	88.5	0.00
Age	1	12,283	6.4	0.02
Education	1	3,564	1.8	0.18
Church	1	3,002	1.6	0.22
Hours of sleep	1	5,125	2.7	0.11
Religiosity	1	4,144	2.1	0.15
Faith maturity	1	2,581	1.3	0.25
Glossolalia	1	9,856	5.1	0.03

$r^2 = 0.73$ (adjusted $r^2 = 0.68$).

tem (Frankenhaeuser, 1979; Lundberg and Frankenhaeuser, 1980). Another position is that the adrenal cortex (HPA) and adrenal medulla (SNS) mediate different behavioral modes, with the former associated with "threats to control," whereas the latter relates to withdrawal behaviors or "loss of control" (Henry, 1980; Henry and Stephens, 1977). The third argument holds that HPA axis activity is related to readjustment to situations beyond the normal or expected (Gunnar, 1986, 1987). These positions are not necessarily mutually exclusive and suggest several interpretations of the current data. The greater sAA (SNS) elevation related to Pentecostal behavior on Sunday can be associated with the arousal of Pentecostal worship (i.e., speaking in tongues, gospel singing, movement), whereas the higher Monday levels may be attributable to more active lives of those relatively more involved in the church. In other words, someone who is more active in the church community might generally lead a more active lifestyle. One recent study found religious older women but not older men or young people likely to exercise and enjoy active lives (Gillum, 2006), whereas another found religious people, in general, more likely to lead a healthy active lifestyle but that this association is less pronounced with age (Hill et al., 2007). This might entail a concomitant elevation in SNS activity. The third position is consistent with the study hypothesis and data in suggesting that cortisol should not be elevated in experienced Pentecostals because ritual religious behavior is repetitious by nature and normalizes behavior and creates predictability.

To better understand these relationships, this study looked at the associations of stress biomarkers and several factors. We found several significant associations with cortisol, whereas sAA was associated only with glossolalia (i.e., Pentecostalism) and age. Given the variations in sAA levels, this suggests that sAA may be sensitive to more factors rather than fewer. Salivary α -amylase levels have been found to increase to a significantly greater degree in response to a stressor than did cortisol in 40% of participants, which Granger et al. (2007) have interpreted as due to a more sensitive threshold of reactivity in the SNS than the HPA axis, such that sAA is produced more readily to milder arousal states than are required for cortisol production (compare Het et al., 2009). Lacks of correlation between salivary cortisol and sAA at baseline, in response to stress, or during recovery have similarly been taken to mean that these biomarkers are indexing different stress-response systems (Chatterton et al., 1996; Granger et al., 2007), an interpretation lent further support by a lack of correlation across the lifecycle (Strahler et al., 2010). This is consistent with previous studies of

cortisol and catecholamines (e.g., Lundberg, 1983). As such, they may be sensitive to different types of arousal. In a study of a collegiate crew team, Kivlighan and Granger (2006) found higher sAA to be positively associated with performance and team bonding. In this dataset, higher levels were observed among those more invested in Pentecostal models of behavior, as indicated by glossolalia behavior (Lynn et al., submitted for publication). These same individuals are also more likely to be active in services and as officers in the church, behaviors that may be comparable with performance and bonding.

CONCLUSION

This study examined the influence of Pentecostalism on stress physiology. Two main findings emerged: (1) there is a trend toward lower salivary cortisol across the diurnal cycle on Monday relative to Pentecostal worship "stress" of Sunday, and (2) there is an increase in sAA from Sunday to Monday, also across a daily cycle but one that is inconsistent with other studies. These data do not resolve the question of whether Pentecostal behavior positively influences health, but they do affirm a moderating influence. Additionally, they are important in the on-going investigation of the relationship of HPA and SNS activity to each other and as an exploration of how these systems behave in a naturalistic religious setting in response to positive-neutral stress.

ACKNOWLEDGMENTS

This study was conducted in partial fulfillment toward the completion of a doctoral degree for the first author at the University at Albany, SUNY. The authors thank the churches that participated and the undergraduate research assistants Angela Brennan, Terrah Bretherton, and Dex Manthey. They also thank Jason DeCaro and two anonymous reviewers for helpful comments on earlier versions of this article.

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