Chronic Physiologic Effects of Stress Among Lesbian, Gay, and Bisexual Adults: Results From the National Health and Nutrition Examination Survey

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ABSTRACT

Objective: Social disadvantage is associated with markers of physiological dysregulation, which is linked to disease trajectories. Chronic experiences with discrimination are thought to result in the accumulation of physiological "wear and tear" known as allostatic load (AL) among socially marginalized populations such as sexual minorities. Using a nationally representative US sample, we examined whether (1) people who self-identified as homosexual or bisexual display higher levels of AL than heterosexual individuals and (2) subgroups of sexual identity would further differ from each other as a consequence of distinct experiences of marginalization.

Methods: We use data from the 2001–2010 National Health and Nutrition Examination Survey. Employing multivariate regression methods with sex-specific analyses, we examined AL score differences among lesbian/gay (n = 211), bisexual (n = 307), homosexually experienced (n = 424), and exclusively heterosexual (n = 12,969) individuals, adjusting for possible confounding due to demographics, health indicators, and, among men, HIV infection status.

Results: Results indicate that elevated AL was more common in bisexual men compared with exclusively heterosexual men (adjusted $\beta = 0.25$, 95% confidence interval [CI] = 0.05 to 0.44), with significantly higher levels of glycosylated hemoglobin A1c (adjusted odd ratio = 3.51, 95% CI = 1.46–7.92) and systolic blood pressure (adjusted odd ratio = 2.07, 95% CI = 1.02 to 4.18). Gay-identified men evidenced significantly lower AL (adjusted $\beta = -0.22$, 95% CI = −0.41 to −0.04). No significant differences in AL were observed among women.

Conclusions: These findings indicate that physiological dysregulation is more common in bisexual males compared with all other men. The results are discussed with regard to differences in health outcomes between individuals with different sexual orientations.

Key words: allostatic load, bisexuality, National Health and Nutrition Examination Study, sexual minority stress, sexual orientation.

INTRODUCTION

A growing body of research documents that sexual minorities experience stress associated with stigma, prejudice, and discrimination that predispose them to negative physical and mental health outcomes (1–7). To date, however, the consequences of these experiences on the health of lesbian, gay, and bisexual (LGB) individuals outside of HIV research have seldom been studied using biological approaches commonly employed in biobehavioral studies. To better understand how physiological indicators of chronic stress operate by sexual minority status differences among LGB subgroups, the current study aims to assess how sexual orientation status relates to allostatic load (AL).

AL refers to the multisystemic "wear and tear" that chronic stress exacts on the brain and body (8). AL is often used to measure this physiological "wear and tear" from the body's efforts to maintain its internal response to stress throughout life (9,10). Seeman and colleagues (11) through a series of pioneering studies demonstrated that over time, the strain of trying to maintain homeostasis in the face of chronic stress can result in the dysregulation of several physiological parameters. In particular, these include inflammatory, cardiovascular, endocrine, metabolic, and autonomic systems (12).

Theoretically under cumulative strain, the biphasic effects of numerous biomarkers lead to AL and disease as follows: (*a*) overactivation of *primary mediators* such as stress hormones (e.g., cortisol) and pro- and anti-inflammatory cytokines (e.g., interleukin 6) induce *primary effects* on cellular activities (13); (*b*) leading to *secondary outcomes*, whereby metabolic, cardiovascular, and second-order immune biomarkers become dysregulated; and (*c*) culminate as *tertiary outcomes* or clinical end points (14). The MacArthur Studies on Successful Aging first indexed AL using 10 neuroendocrine, immune, metabolic, and

AL = allostatic load, **BMI** = body mass index, **CI** = confidence interval, **LGB** = lesbian, gay, and bisexual, **NHANES** = National Health and Nutrition Examination Survey

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cardiovascular biomarkers that were predictive of increased physical/cognitive declines and incident cardiovascular disease (11). After nearly two decades of research, AL algorithms have been robustly related to numerous social antecedents in dozens of studies worldwide (for reviews, see Juster et al. (15) and Beckie (16)). In particular, social disadvantage is associated with elevated AL, which is linked to various physical and mental disease trajectories (17).

Epidemiological evidence that AL is an effective tool to monitor population-level chronic stress and health associations have come from the National Health and Nutrition Examination Survey (NHANES). Over the lifespan, Americans living in poverty manifest the sharpest increases in AL up until middle and older age, when AL levels plateau (18). This plateau is due in part to selective mortality among the most socially disadvantaged. Furthermore, life expectancy is 6 years shorter for those with the most elevated AL levels, as compared with those who evidence lower AL levels (19). Understanding how social inequalities in populations relate to AL provides insights into the pathways whereby the social determinants of health lead to physiological dysregulation and subsequent clinical end points (20).

One rationale for the current study on sexual minority statuses (e.g., LGB) is supported by findings of the relationship between experiences of discrimination and stress in racial/ethnic minorities and negative health-related physiological outcomes. Studies support that AL is elevated among racial/ethnic minorities often with African-Americans experiencing some of the highest odds of adverse health outcomes (21). In a multirace/ethnic NHANES analysis, black men and women evidenced higher AL levels than white individuals, which in turn contributed to an overall greater risk for cardiovascular- and diabetes-related mortality (22). These findings and others demonstrate that social inequalities experienced by racial/ethnic minorities contribute to cumulative stress that can be captured with AL algorithms (23–25). Similar to racial/ethnic minorities in which high levels of discrimination and hostility significantly predicted higher levels of AL (23), sexual minorities are expected here to experience chronic stress based on prejudice, stigma, and discrimination.

Social inequalities are related to AL because they represent cumulative adversities that strain the body and mind over time (20). Cumulative disadvantage theory describes the systemic tendency for interindividual divergence in a given characteristic—such as social or health status—to be experienced in a socially unjust way over time (26). For instance, race/ethnic inequalities are linked to cumulative disadvantage that is associated with an accumulation of negative health outcomes throughout life (12,27). Depending on the sociocultural contexts, these adverse outcomes may also manifest themselves at specific ages among vulnerable populations (28). This is consistent with the "weathering hypothesis" (29) that states that black women's health deteriorates earlier in adulthood as the physical consequence of cumulative social disadvantage. Using the NHANES to confirm weathering health inequality, black women were indeed shown to have the most consistently elevated AL across age groups (9). The experiences of minority status represent a cumulative strain that shapes stress sensitivities, which can exacerbate AL further and promote disease.

Consistent with literature on cumulative disadvantage as a social determinant of health, the LGB health literature has been framed according to minority stress theory that is only beginning to be assessed using stress biomarkers as indicators of cumulative strain. Sexual minority stress models (5,30,31) propose that the stress experienced by LGB individuals comes from two sources of stigma over and above general life stressors experienced by everybody (32). First at the individual level, *proximal minority stress processes* refers to internalized homophobia and concealment of one's sexual orientation or gender identity for transgender individuals (33). Second at the social level, *distal minority stress processes* refers to stressors such as discrimination and violence that disproportionately affect LGB individuals.

Two recent studies exemplify how both distal and proximal stress processes influence physiological outcomes in LGB samples. First, Doyle and Molix (34) showed that discrimination predicts elevated interleukin-6 levels in gay men; however, this relationship was present only among gay men who engaged in less covering, a strategy that involves downplaying one's stigmatized identity. Second, Parra and colleagues (35) showed that LGB-related stressful life events, internalized homonegativity, and flatter diurnal cortisol slopes were positively associated with depressive symptoms. Apart from these studies, it is unknown to what extent distal (e.g., macro-level stigma) and proximal (e.g., micro-level distress) sexual minority stress processes affect multisystemic biomarker profiles among LGB subgroups.

Emerging research shows that AL may differ by sexual orientation. In a convenience sample of 87 Canadians, Juster and colleagues (36) first showed that sexual minorities do not manifest heightened stress pathophysiology when compared with heterosexuals. Quite to the contrary, sexual minority men had lower AL levels than heterosexual men, but no such differences were found among women (36). Lower AL among the sexual minority men was driven by lower values of triglycerides, body mass index (BMI), and tumor necrosis factor α in comparison with heterosexual men. Interestingly, LGB participants who had fully disclosed their sexual orientation to family and friends showed significantly lower symptoms of depression, anxiety, and burnout as well as lower concentrations of the stress hormone cortisol 30 minute after awakening compared with LGB individuals who had not completely disclosed (36). A separate analysis of only LGB participants revealed that those who engaged in avoidance coping strategies during their sexual identity formation and disclosure processes evidenced elevated AL, whereas those who sought social support experienced less perceived stress (37).

Stigma-related stress can promote adaptive behavioral responses among stigmatized individuals that successfully appropriate their identities, which may render some more resilient (38). Despite this possibility for gay men, a key limitation in the study by Juster and colleagues was that bisexual men were underrepresented and were therefore collapsed in analyses with gay men. Likewise, lesbian and bisexual women were combined because of restricted power that may have compromised the ability to detect AL differences among women. While this analytic approach is common in small studies, it is important to investigate potential differences between LGB subgroups. In particular, there is evidence that bisexual individuals experience the greatest health disparities (1).

Bisexuality is a minority within the sexual minority population. It is possible that bisexual individuals experience alienation and stigmatization from both heterosexual and homosexual communities (39). Consistent with this hypothesis, research has shown that

bisexual men and women report significantly lower levels of connection to their community than their lesbian and gay peers (40). Similarly, "homosexually experienced heterosexual" individuals (41) are those who fall between heterosexual and bisexual individuals on spectrum of sexual orientation, attractions, and behaviors. This represents another understudied group with their own unique experiences that have yet to be investigated using stress biomarkers. According to a systemic review, homosexually experienced heterosexuals also experience psychological and physical health problems that are greater than heterosexual individuals but lower than bisexual individuals (42).

The current study investigated AL differences as a function of sexual orientation using the population sample public data NHANES while adjusting for key covariates. First, we hypothesized that bisexual men and women would evidence higher AL than heterosexual men and women based on studies indicating high levels of stress in bisexual individuals (1). Second, we explored whether gay men differed in AL, as compared with heterosexual and bisexual men. Third, we explored whether lesbians would show higher AL than heterosexual women consistent with sexual minority stress theory (5,31,43). Finally, we included a fourth stratification of homosexually experienced individuals of both sexes that otherwise identified as heterosexual to contrast potential gradients in AL as a function of sexual behavior. These hypotheses are based on studies of racial/ethnic minorities in which findings indicate frequent activation of the physiological stress response systems that can be manifested as AL (44).

METHODS

Data Source and Sample

We use publicly available data from the 2001–2010 National Health and Nutrition Examination Survey (NHANES). The NHANES is a continuous population-based health survey conducted by the National Center for Health Statistics and released in 2-year cycles. The NHANES sample is representative of the civilian, noninstitutionalized US population aged 2 months and older. Beginning in 2001, the NHANES included assessments of sexual orientation identity for individuals aged 14 years and older with varying upper age limits depending on the survey cycle.

Availability of sexual orientation assessment varies in the publicly released survey cycles across different age ranges. As such, we limit the current analysis to participants between ages 20 to 59 years (n = 18,014), as this is the age cohort consistently included in all five of the NHANES cycles. Of those age-eligible individuals, 15,361 were administered the sexual behavior modules described more fully hereinafter. From this latter group, we excluded 870 women who were pregnant at the time of the NHANES examination, because this may have affected biological markers key to the current study. An additional 580 persons were excluded because they did not have their blood drawn (n = 519), were not measured for height, weight, and blood pressure (n = 13), or provided insufficient information to be coded for sexual orientation (e.g., denied being sexually active and did not report a heterosexual, gay, or bisexual identity; n = 48). This resulted in a final sample size of 13,911. Further information on the NHANES data sets are described elsewhere (30).

Sexual Orientation

The NHANES assessed both sexual orientation identity (e.g., heterosexual, lesbian/gay, bisexual) and the sex of sexual partners since the age of 18 years and in the year before interview. Following procedures suggested by the National Center for Health Statistics, we logically recoded several individuals who were skipped out of the detailed sexual history assessment (n = 492). These persons did not affirmatively acknowledge being sexually experienced but were queried as to their sexual orientation identity. Those who reported a current marital status most likely reflective of previous or current heterosexuality (i.e., married, widowed, divorced, separated: n = 339) or, for women, a history of being pregnant (n = 153) were coded as having a positive lifetime history of opposite-sex sexual partners.

Participants were next grouped as follows: (*a*) those reporting a lesbian or gay identity, regardless of sexual history (n = 211); (*b*) those reporting a bisexual identity, regardless of sexual history (n = 307); (*c*) those indicating positive lifetime histories of same-sex sexual partners (homosexually experienced; n = 424) in the absence of a current lesbian, gay, or bisexual identity (92% currently identified as heterosexual); or (*d*) exclusively heterosexual (n = 12,969) including those who explicitly self-identified as heterosexual (n = 12,671) or reported no same-sex sexual partners or gay/bisexual identity (n = 282) or, barring that, evidenced marital and reproductive histories consistent with heterosexuality (n = 15)(45). Although we did not include participants who reported "something else," "not sure," "don't know," or "refused," these subgroups represent yet another layer of complexity in sexual orientation of significance (46).

Allostatic Load

Across the five survey cycles of interest, the NHANES consistently measured nine biomarkers that are commonly used to index AL (15). These represent cardiovascular (systolic and diastolic blood pressure, resting heart rate), metabolic (glycosylated hemoglobin, BMI, total cholesterol, high-density lipoprotein cholesterol), and immune (serum albumin, C-reactive protein) functioning. Consistent with previously reported strategies that index physiological dysregulations using clinical reference ranges (36,47), we first scored individuals as positive or not for each of the nine biomarkers individually using standard clinical cut-offs as previously applied in NHANES analyses of AL (18,19,21). Clinical ranges were provided by NHANES laboratory protocol manuals as well as supplemental documents routinely used (48–50). AL was then indexed by a count of positive biomarkers (range = 0–9).

The cut-offs used are as follows: systolic blood pressure ≥ 140 mm, diastolic blood pressure ≥ 90 mm, resting heart rate ≥ 90 beats/min, glycosylated hemoglobin ≥ 6.4%, BMI ≥ 30 kg/m^2, total cholesterol ≥ 240 mg/dL, high-density lipoprotein cholesterol < 40 mg/dL, serum albumin < 3.8 g/dL, and C-reactive protein > 0.3 mg/dL. Respondents who reported that they were currently taking medication for high blood pressure, cholesterol lowering drugs, or diabetes medication or insulin injections were scored positive for the two blood pressure biomarkers, total cholesterol, and/or glycosylated hemoglobin, respectively, regardless of laboratory values.

Detailed information for the NHANES examination and laboratory protocols are available on the Center for Disease Control's Web site (https://www.cdc.gov/nchs/nhanes/index.htm). As part of the examination, three to four resting blood pressure and heart rate measurements were taken in the mobile examination center and during home examinations on all eligible individuals using the Baumanometer calibrated mercury true gravity wall model or portable desk model sphygmomanometer along with the Littman Cardiology III stethoscopes. Height and weight used to calculate BMI were obtained by trained health technicians who recorded values as a team in a specially equipped room of the NHANES mobile examination center.

The following information summarizes laboratory protocols. Whole blood glycohemoglobin measurements were performed using the A1c 2.2 Plus Glycohemoglobin Analyzer and during the survey cycle by A1c G7 HPLC Glycohemoglobin Analyzer (Tosoh Medics Inc, San Francisco, CA). Specimens destined for cholesterol and albumin measurement were processed, stored, and shipped to the University of Minnesota, Minneapolis, Minnesota, for analysis. Cholesterol was analyzed using the Roche Modular P chemistry analyzer using protocols specified by the manufacturer. Albumin was quantified with solid-phase fluorescent immunoassay with a standard curve ranging from 0.5 to 20 μg/ml. Blood specimens destined for C-reactive protein measurement were processed, stored, and

shipped to University of Washington, Seattle, Washington. Serum ultrasensitive C-reactive protein was quantified using the Behring latex–enhanced nephelometric technique that yields a lower detection limit of 0.02 ng/ml.

Health Indicators

The NHANES also measured several health-related indicators that are robust covariates in studies of both sexual orientation (1) and AL (15). These included health insurance status (coded as has current coverage or not), tobacco smoking (coded as current smoker or not), and levels of mental distress.

Mental distress was assessed in the NHANES using a single item from the Center for Disease Control and Prevention HRQOL-4 "Healthy Days Measure" (51). Respondents reported how many days in the past 30 days that their mental health was "not good." Those reporting 14 or more days were coded as experiencing frequent mental distress.

In addition, the NHANES measured reports of leisure time exercise that has been shown in previous studies to be associated with AL levels (52), although its association with sexual orientation is somewhat unclear (53–55). Respondents who reported that they had not engaged in either vigorous and/or moderate leisure time exercise lasting 10 minutes or more were coded as not exercising. For the five survey cycles, the time frame for the questions varied between 30 days before interview (2001–2006) and "in a typical week" (2007–2010).

Finally, information on prevalent HIV infection is also available in the public data set, but only for individuals aged 20 to 49 years. Because HIV infection was quite rare among sexual minority women (only 2 individuals are reported across 10 years of NHANES data), analyses focusing on the possible contribution of HIV infection to AL were limited to men in the sample.

Demographics

The NHANES also collected information on respondents' sex and race/ethnicity. The latter was coded as non-Hispanic white versus racial/ethnic minority. Several other demographic characteristics, causally unrelated to sexual orientation in AL studies (15), were also considered as possible confounders. These included age, foreign birth, and educational attainment. All have been shown to be associated with sexual orientation (56,57), as well as indicators of mental health morbidity (58–64) and AL (15). We also took into consideration possible measurement and temporal variance for the two survey cycles.

Analytic Approach

Analyses were conducted in Stata 11 (65) using design information and sample weights. Missing data were imputed by iterated chained equation (ICE) methods. In the first set of analyses, we used linear or logistic regression, as appropriate, to evaluate sexual orientation–linked differences in demographic characteristics, discrimination experiences, mental health morbidity, and substance use behaviors. In conducting analyses of discrimination and morbidity measures, we adjusted for possible demographic (age, race/ethnicity, educational attainment, and foreign birth) and survey cycle confounding effects. For analyses of summary AL counts, we used

TABLE 1. Demographic Characteristics of US Adults, Aged 20 to 59 Years, by Sexual Orientation, NHANES (2001–2010)

	Gay (n = 211)		Bisexual (n = 307)		Homosexually Experienced (n = 424)		Exclusively Heterosexual (n = 12,969)	
Characteristics	%	(SE)	%	(SE)	%	(SE)	%	(SE)
Female sex**	38.8	(5.4)	68.2	(3.2)	67.1	(2.6)	48.2	(0.4)
Age, y**								
20–29	20.8	(2.8)	35.8	(3.7)	23.4	(2.3)	23.3	(0.6)
30–39	31.6	(3.7)	27.9	(3.3)	26.3	(2.5)	23.9	(0.5)
40–49	39.8	(4.4)	21.6	(2.6)	27.4	(2.8)	28.5	(0.5)
50–59	17.8	(4.3)	14.6	(2.2)	22.8	(2.8)	24.2	(0.6)
Educational attainment**								
Less than high school	7.1	(1.9)	18.5	(3.0)	12.6	(1.6)	16.0	(0.6)
High school degree	12.0	(2.6)	23.2	(2.4)	17.2	(2.5)	24.5	(0.6)
Some college	33.8	(4.7)	37.8	(3.2)	43.2	(3.2)	32.3	(0.6)
College degree	47.2	(5.3)	20.5	(3.0)	27.0	(2.4)	27.2	(0.9)
Race/ethnicity								
Non-Hispanic white	73.4	(3.6)	72.3	(2.9)	72.1	(2.6)	69.6	(1.4)
Hispanic	9.6	(1.8)	10.6	(1.7)	11.0	(1.4)	14.1	(1.1)
Non-Hispanic black	9.8	(1.7)	14.2	(1.9)	11.2	(1.4)	11.0	(0.8)
Non-Hispanic other/multiracial	7.1	(2.2)	2.9	(1.0)	5.7	(1.2)	5.3	(0.4)
Family income as percent of FPL*								
Below FPL	10.3	(1.9)	24.2	(2.9)	15.3	(1.9)	13.4	(0.5)
100%–199% of FPL	16.4	(2.6)	22.2	(2.4)	20.3	(1.9)	18.1	(0.5)
200%–299% of FPL	15.0	(3.0)	20.6	(2.9)	15.1	(2.4)	14.3	(0.5)
300%–300% of FPL	11.4	(2.4)	10.4	(2.1)	13.5	(2.0)	14.8	(0.5)
≥400% of FPL	46.8	(5.6)	22.6	(3.0)	35.8	(3.2)	39.3	(1.0)
Foreign birth*	10.7	(2.4)	8.0	(1.6)	10.5	(1.5)	16.2	(1.0)

SE = standard error; FPL = federal poverty level.

N = 13,959. Percentages sum to 100% except for rounding error. Statistical significance evaluated by multinomial regression regressing sexual orientation status on all demographic characteristics and survey cycle considered simultaneously.

*$p < .05$.

**$p < .001$.

negative binomial regression methods for men and women separately, as well as for men, aged 20–49 years, who were assessed for HIV infection. We present two sets of models. The first adjusts for confounding due to demographic factors and survey cycle. The second model further adjusts for health indicators. In the text, we report weighted prevalences and means, and their standard errors, standardized betas, adjusted odds ratios, and results from Wald F tests. Significance of all tests was evaluated at $p < .05$ level. All reported confidence intervals are at 95% confidence. Given our focus on within-sex/gender variation as a function of sexual orientation, our statistical analyses were conducted for men and women separately as previously justified (66).

RESULTS

Individual Characteristics Associated With Sexual Orientation

Approximately 6.8% (95% confidence interval [CI] = 6.2%–7.5%) of the weighted respondents reported either a lesbian/gay (1.7%, 95% CI = 1.3%–2.0%) or bisexual identity (2.1%, 95% CI = 1.8%–2.4%), or, in their absence, same-sex sexual partners since age of 18 years (3.1%, 95% CI = 2.6%–3.5%) (Table 1). Several characteristics that might confound associations between measures of AL and sexual orientation varied significantly by sexual orientation status. Such characteristics include sex (adjusted Wald F (3) = 26.76, $p < .001$), age (adjusted Wald F (9) = 2.88, $p < .05$), level of education (adjusted Wald F (9) = 6.12, $p < .001$), foreign birth (adjusted Wald F (3) = 5.90, $p < .05$), family income (adjusted Wald F (12) = 3.22, $p < .001$), and survey cycle (adjusted Wald F (12) = 2.71, $p < .05$). Notably, significant differences in racial/ethnic backgrounds were not observed (adjusted Wald F (9) = 0.67, $p = .74$).

Sexual Orientation Differences in Health Indicators

Sexual orientation among men was associated with differences in prevalence of frequent mental distress (adjusted Wald F (3) = 13.17, $p < .001$) and weekly binge drinking (adjusted Wald F (3) = 2.73, $p = .05$) (Tables 2, 3). However, similar effects were not observed for prevalence of health insurance coverage (adjusted Wald F (12) = 1.39, $p = .25$), leisure time exercise (adjusted Wald F (3) = 0.43, $p = .73$), or current smoking (adjusted Wald F (3) = 1.96, $p = .13$) although focused contrasts indicate that gay men were significantly more likely to be current smokers than exclusively heterosexual men. Prevalence of HIV infection was strongly associated with sexual orientation among men aged 20 to 49 years (adjusted Wald F (12) = 58.77, $p < .001$). Among women, health insurance coverage (adjusted Wald F (3) = 2.76, $p < .05$), frequent mental distress (adjusted Wald F (3) = 7.14, $p < .001$), weekly binge drinking (adjusted Wald F (3) = 12.33, $p < .001$), and reports of current smoking (adjusted Wald F (3) = 17.56, $p < .001$) were associated with sexual orientation, although similar to men leisure time exercise (adjusted Wald F (3) = 0.42, $p = .74$) was not.

Sexual Orientation Differences in AL

Figure 1 illustrates the weighted mean AL for the sample (Table 3). Among men, sexual orientation was associated with AL (adjusted Wald F (3) = 3.75, $p < .05$). After we adjusted for confounding, gay men had significantly lower levels of AL compared with men who identified as exclusively heterosexual (Table 4). In contrast, bisexual men evidenced significantly higher levels of AL compared with exclusively heterosexual men. When we restricted our sample to men aged 20–49 years, this relationship was attenuated for gay men, but not for bisexual men.

Among specific biomarkers comprising AL, there were statistically significant sexual orientation–related differences in high systolic blood pressure (adjusted Wald F (3) = 3.37, $p < .05$), elevated glycosolated hemoglobin (adjusted F (3) = 5.37, $p < .05$), and high diastolic blood pressure (adjusted Wald F (3) = 3.80, $p < .05$). Specifically, gay men evidenced significantly lower levels of glycosolated hemoglobin (Table 3) and systolic blood pressure compared with exclusively heterosexual men. By contrast, bisexual men had significantly higher levels of glycosolated hemoglobin and systolic blood pressure than men who identified as exclusively heterosexual. Homosexually experienced men evidenced significantly lower levels of diastolic blood pressure compared with exclusively heterosexual men.

Among women, sexual orientation was not associated with AL (adjusted Wald F (3) = 0.51, $p = .67$). There were no statistically significant differences in AL for lesbian women, bisexual women, or homosexually experienced women, compared with exclusively heterosexual women. However, there were significant sexual orientation–related differences among specific indices of AL, including BMI consistent with obesity (adjusted Wald F (3) = 1.91, $p = .08$) and low albumin (adjusted Wald F (3) = 2.21, $p = .09$). Specifically, bisexual women were more likely to have a higher BMI and lesbian women were more likely to have lower levels of albumin compared with women who identified as exclusively heterosexual.

DISCUSSION

The current study assessed whether physiological dysregulations measured using AL indices differs by sexual orientation in a large population-based sample. We found that subgroup differences in AL only among men where gay men showed the lowest AL levels and bisexual men showed the highest AL in comparison with exclusively heterosexual men. No differences in AL were found among women or among homosexually experienced heterosexuals of either sex. We theorize that social marginalization affects both pathogenic and/or salutogenic processes that contribute to AL profiles in unique ways within subgroups of sexual minorities.

Our results are consistent with an earlier study by Juster and colleagues (36) showing that gay men evidence lower AL levels compared with heterosexual men and where women show no AL differences. These results do not, however, concur with the only other known published study of AL and sexual orientation from the United States. In an analysis by Hatzenbuehler and colleagues (67) of 306 LGB and 6667 heterosexual young adults from the National Longitudinal Study for Adolescent Health (ADD HEALTH), LGB individuals did not show differences in AL compared with heterosexuals. Among LGB individuals only, more stressful life events spanning childhood to emerging adulthood predicted elevated AL based on blood pressure, pulse, C-reactive protein, glycosylated hemoglobin, and waist circumference (67). Another ADD HEALTH analysis of individual biomarkers found that gay/bisexual men had higher C-reactive protein, diastolic blood pressure, and pulse, but lower glycosylated hemoglobin compared with heterosexual men (68). These studies did not, however, examine cardiometabolic biomarkers or AL indices differentially between LGB subgroups. Our study expands measurement

TABLE 2. Health Indicators and Markers of AL Among US Adults, Aged 20–59 Years, by Gender and Sexual Orientation: Weighted Estimates and Standard Errors Shown, NHANES (2001–2010)

	Women								Men							
	Gay (n = 87)		Bisexual (n = 201)		Homosexually Experienced (n = 272)		Heterosexual (n = 6230)		Gay (n = 124)		Bisexual (n = 106)		Homosexually Experienced (n = 152)		Heterosexual (n = 6739)	
	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)	%	(SE)
Health indicators, %																
Currently insured	70.6	(5.1)	67.4	(3.8)	80.0	(2.7)	81.0	(0.8)	88.6	(2.9)	65.8	(4.9)	70.5	(3.9)	74.5	(0.7)
Lack of exercise	38.4	(5.3)	37.5	(2.9)	39.0	(4.0)	36.4	(0.9)	19.6	(4.2)	38.1	(5.5)	32.4	(4.5)	34.3	(1.1)
Current smoker	37.5	(5.9)	46.1	(3.4)	42.8	(3.7)	23.0	(0.8)	29.8	(5.1)	40.2	(6.1)	30.5	(4.5)	29.5	(0.8)
Frequent mental distress	13.0	(3.6)	30.0	(3.5)	20.2	(3.1)	14.8	(0.5)	12.4	(3.4)	23.7	(4.3)	18.5	(3.5)	9.3	(0.4)
Weekly binge drinking	1 0.9	(3.3)	11.9	(2.3)	9.2	(2.1)	3.3	(0.2)	3.4	(1.7)	23.2	(5.5)	16.0	(3.3)	16.5	(0.7)
Prevalent HIV infection[a]									14.7	(3.8)	6.7	(2.1)	0.7	(0.7)	0.2	(0.1)
AL indicators, %																
Albumin < 3.8 g/dL	2.0	(1.2)	6.2	(2.0)	7.2	(1.7)	7.5	(0.4)	1.7	(1.2)	2.5	(2.0)	1.1	(0.6)	1.5	(0.2)
C-reactive protein > 0.3 mg/dL	41.0	(6.2)	45.2	(4.1)	38.8	(3.2)	40.0	(0.9)	18.4	(4.3)	36.5	(6.7)	20.2	(4.0)	25.5	(0.7)
BMI ≥ 30 kg/m[b]	41.3	(5.3)	44.5	(4.8)	29.0	(3.0)	34.5	(0.8)	24.4	(4.3)	38.6	(5.2)	27.8	(4.0)	32.0	(0.8)
Total cholesterol ≥ 240 mg/dL	10.1	(3.2)	13.3	(3.2)	17.1	(2.4)	13.4	(0.6)	13.6	(3.5)	13.1	(3.8)	19.7	(3.2)	15.5	(0.6)
HDL cholesterol < 40 mg/dL	15.1	(3.8)	16.1	(2.9)	13.3	(3.2)	10.6	(0.5)	32.5	(4.8)	36.3	(6.2)	26.1	(4.0)	30.2	(0.7)
Glycosolated hemoglobin ≥ 6.4%	6.3	(4.7)	3.4	(1.7)	5.8	(1.8)	4.6	(0.3)	0.6	(0.4)	16.4	(4.8)	4.7	(2.0)	5.3	(0.4)
Resting heart rate ≥ 90 beats/min	11.6	(3.5)	14.8	(3.2)	13.6	(3.0)	11.1	(0.4)	7.7	(2.6)	14.4	(4.4)	11.9	(3.5)	7.9	(0.4)
Systolic blood pressure ≥ 140 mm	11.0	(4.2)	5.8	(2.2)	4.1	(1.3)	7.6	(0.4)	2.2	(1.3)	17.6	(4.7)	9.2	(3.0)	9.0	(0.4)
Diastolic blood pressure ≥ 90 mm	4.9	(2.9)	3.7	(1.8)	2.0	(1.1)	3.8	(0.3)	3.9	(1.5)	8.1	(3.4)	2.8	(1.2)	7.5	(0.4)
AL,[b] mean	1.62	(0.22)	1.65	(0.14)	1.53	(0.13)	1.63	(0.03)	1.22	(0.13)	2.13	(0.22)	1.54	(0.15)	1.62	(0.03)

SE = standard error; AL = allostatic load; BMI = body mass index; HDL = high-density lipoprotein.

N = 13,959. Percentages sum to 100% except for rounding error.

[a] Among men aged 20–49 y only. Females not shown due to rarity of HIV infection among sexual minority women; sample includes gay, bisexual men, homosexually experienced, and exclusively heterosexual men only.

[b] AL estimated as a sum of biologic indicators scored positive.

TABLE 3. Sexual Orientation Differences in Health Indicators and Markers of AL Among US Adults, Aged 20 to 59 Years, by Gender: Adjusted Odds Ratios[a] and 95% CIs Shown, NHANES (2001–2010)

	Women			Men		
Health Status	Gay	Bisexual	Homosexually Experienced	Gay	Bisexual	Homosexually Experienced
Health indicators						
Currently insured	0.57 (0.33–0.97)	0.61 (0.41–0.92)	0.92 (0.64–1.32)	1.50 (0.80–2.84)	0.76 (0.42–1.34)	0.70 (0.41–1.21)
Lack of exercise	1.15 (0.90–1.49)	0.96 (0.74–1.26)	1.19 (0.83–1.70)	0.80 (0.45–1.40)	1.07 (0.68–1.69)	0.92 (0.62–1.34)
Current smoker	1.91 (1.17–3.14)	2.18 (1.56–3.04)	2.56 (1.82–3.62)	1.82 (1.03–3.08)	1.52 (0.91–2.55)	1.20 (0.78–1.85)
Frequent mental distress	0.80 (0.42–1.54)	2.16 (1.52–3.08)	1.38 (0.90–2.12)	1.90 (0.98–3.67)	2.79 (1.76–4.44)	2.26 (1.40–3.65)
Weekly binge drinking	3.19 (1.54–6.61)	2.58 (1.68–3.96)	2.50 (1.41–4.42)	0.25 (0.09–0.72)	1.50 (0.78–2.87)	1.07 (0.66–1.75)
Prevalent HIV infection (men only aged 20–49 y)*				395.38 (144.01–1085.51)	47.66 (18.46–123.09)	3.16 (0.34–29.42)
AL indicators						
Albumin < 3.8 g/dL	0.22 (0.07–0.75)	0.74 (0.36–1.55)	0.91 (0.53–1.56)	1.36 (0.35–5.25)	1.31 (0.24–7.25)	0.66 (0.23–1.89)
C-reactive protein > 0.3 mg/dL	1.03 (0.60–1.74)	1.22 (0.86–1.72)	0.98 (0.75–1.28)	0.77 (0.43–1.39)	1.59 (0.85–2.95)	0.69 (0.41–1.16)
BMI ≥ 30 kg/m^2	1.34 (0.82–2.19)	1.51 (1.01–2.26)	0.76 (0.57–1.02)	0.71 (0.44–1.15)	1.32 (0.85–2.05)	0.75 (0.50–1.12)
Total cholesterol ≥ 240 mg/dL,	0.79 (0.36–1.69)	1.35 (0.75–2.43)	1.48 (1.01–2.19)	0.85 (0.46–1.57)	0.81 (0.42–1.60)	1.27 (0.84–1.92)
HDL cholesterol < 40 mg/dL	1.43 (0.78–2.61)	1.27 (0.83–1.94)	1.25 (0.73–2.13)	1.33 (0.84–2.10)	1.30 (0.75–2.26)	0.81 (0.53–1.24)
Glycosolated hemoglobin ≥ 6.4%	1.75 (0.41–7.46)	1.27 (0.40–4.02)	1.58 (0.76–3.30)	0.13 (0.26–0.66)	3.51 (1.46–7.92)	0.75 (0.30–1.90)
Resting heart rate ≥ 90 beats/min	0.96 (0.49–1.88)	1.07 (0.63–1.81)	1.12 (0.69–1.82)	1.20 (0.58–2.50)	1.80 (0.86–3.78)	1.54 (0.79–3.01)
Systolic blood pressure ≥ 140 mm	1.83 (0.74–4.51)	1.38 (0.54–3.50)	0.57 (0.29–.1.14)	0.24 (0.07–0.86)	2.07 (1.02–4.18)	0.92 (0.44–1.92)
Diastolic blood pressure ≥ 90 mm	1.33 (0.41–4.32)	1.36 (0.46–3.98)	0.58 (0.19–1.74)	0.36 (0.12–1.02)	1.02 (0.42–2.46)	0.31 (0.13–0.74)

AL = allostatic load; BMI = body mass index; HDL = high-density lipoprotein.

N = 13,959. Numbers in parentheses are CIs. Sexual orientation differences estimated by logistic regression, adjusted for age, race/ethnicity, family income, educational attainment, foreign birth, and insurance status.

[a] Referent is exclusive heterosexuals.

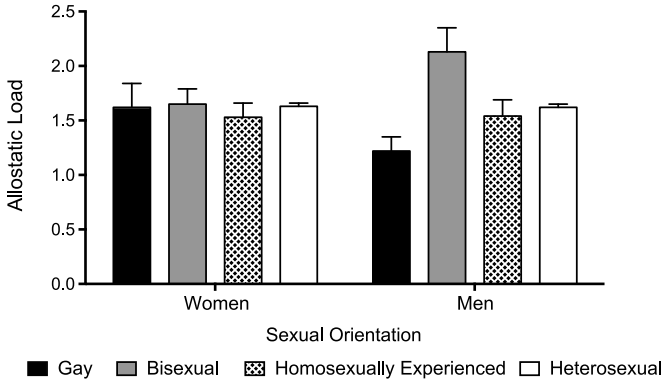

FIGURE 1. Weighted mean (SE) AL as a function of sexual orientation stratified by sex.

factors in this literature and indicates a need for future studies to analytically divide within sex (if sufficiently powered to do so) when assessing stress biomarkers and AL.

The findings from the current study and those of Juster and colleagues (36) suggest that gay men evidence lower levels of AL compared with heterosexual men. This is not consistent with a sexual minority stress framework. There may be a number of ways that the status of being a sexual minority presents a unique set of conditions accounting for differences both between sexual minorities and heterosexuals and within sexual minorities by sex. It may be the case that the health disparities experienced by gay men are not mediated by physiological dysregulation per se but may be influenced through other psychosocial pathways. Indeed, a critical feature in the Hatzenbuehler and colleagues AL study (67) was the analytic combination of stressful life events in conjunction with sexual minority status that together were associated with cardiometabolic risk factors.

An often-unaddressed factor to consider in the minority stress literature is life-course perspectives. Within racial/ethnic minority groups, for example, the stress of being treated badly, differently, or poorly begins in early childhood. The stress-health dysregulating hypothesis in racial/ethnic minorities, particularly African Americans, is also highly related to macroeconomic conditions, which may be quite different for nonracial/ethnic minority gay men. Brody et al. (12) found that for African American adolescents, societal-level economic conditions are related to immune and physiological processes (e.g., AL, cellular epigenetic aging). Examining within gay men the extent to which these socioeconomic conditions are present and play a role may be important in future efforts to identify how stress, minority, sex/gender (69), objective and subjective SES statuses (70), and physiologic processes cluster to protect or confer risk for negative physiological health outcomes. Another reason for the lack of elevated AL findings may be related to the length of time of being or identified with a sexual minority status as AL is based on a "wear and tear" premise over time. Knowing more about age of "coming out," recognition of sexual minority status as well as how milestones of the sexual minority development process (71) are implicated in the AL process would be helpful.

We also know that psychosocial resources such as support networks can also influence AL (72) in ways that can promote risk and/or protection. Brody et al.'s (12) study of racial/ethnic minority adolescents found that even in the face of difficult socioeconomic conditions, strong parental emotional support served to offset some risk for cardiovascular disease, inflammatory, neuroendocrine, and metabolic risk for diseases and disorders (44). Including peer networks and social capital of neighborhoods in gay men may be useful areas for future consideration. In our study, we adjusted for psychological distress and key health and demographic factors; however, the NHANES does not measure many of the factors that we advocate would benefit in better understanding AL, sex/gender, and sexual minority status to refining our knowledge of gay men's stress and AL.

There is also another explanation that may be a factor in accounting for why gay men show lower levels of AL, which involves their experiences of socially reinforced ideals of body thinness and muscularity that influence their health behaviors. Compared with exclusively heterosexual men, gay-identified men evidenced lower BMI (73) and, in the current study, glycosylated hemoglobin while adjusting for exercise and other health behaviors. Although this represents a more favorable metabolic profile, these differences may be related to sociocultural beliefs regarding body image ideals among gay men (74). Indeed, gay men are more likely to endorse a muscular physique (75), disordered eating (76,77), and experience body dissatisfaction compared with both heterosexual men (54,55) and bisexual men (56). As early as adolescence, being a sexual minority male influences attitudes and perspectives about weight, muscularity, and body image (78). Future studies may consider investigating subgroup differences in body image–related behaviors (e.g., exercise, body fat, eating patterns, eating disorders) to further explicate influencing factors in AL variations among gay men.

In our study, bisexual men evidenced significantly higher levels of AL compared with exclusively heterosexual men. A growing number of studies suggest that among sexual minorities, bisexual individuals experience higher levels of psychological distress and are at greater risk for poor health outcomes compared with other sexual minorities and heterosexuals who have poor health status (79–81). Bisexual men show the poorest self-rated health (82) and engage in more unhealthy behaviors that increase risk of cardiovascular disease (83). Elevated AL among bisexual men in the current study may represent their elevated levels of stress associated with their minority status and lower levels of support within diverse communities.

A recent study revealed that bisexual individuals were more likely to report lower levels of community connection and self-disclosure and higher levels of identity confusion (40). In a 2015 Pew Research Center survey, bisexuals were significantly less likely than gay men or lesbians to be out to people important to them (84). Only 28% of bisexuals say people in their life know they are bisexual, which stood in comparison with 77% of gay

TABLE 4. Predictors of AL among US Adults Aged 20 to 59 Years, by Gender, NHANES (2001–2010): Partial Results Shown

	Women		Men			
			Total Sample		Age 20–49 y Only	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 3
	Adj β (CI)	Adj β (CI)	Adj β (CI)	Adj β (CI)	Adj β (CI)	Adj β (CI)
Sexual orientation[a]						
Gay/lesbian	0.00 (−0.20 to 0.21)	0.02 (−0.19 to 0.23)	−0.21 (−0.42 to −0.01)	−0.22 (−0.41 to −0.04)	−0.19 (−0.43 to 0.06)	−0.21 (−0.45 to 0.02)
Bisexual	0.10 (−0.08 to 0.29)	0.11 (−0.08 to 0.30)	0.25 (0.05 to 0.45)	0.25 (0.05 to 0.44)	0.30 (0.06 to 0.54)	0.29 (0.04 to 0.53)
Homosexually experienced	−0.03 (−0.19 to 0.13)	−0.03 (−0.19 to 0.12)	−0.12 (−0.31 to 0.07)	−0.12 (−0.30 to 0.06)	−0.20 (−0.43 to 0.04)	−0.20 (−0.43 to 0.04)
Health indicators						
Currently insured		0.17 (0.09 to 0.25)		0.16 (0.09 to 0.23)		
Current smoker		0.01 (−0.05 to 0.07)		−0.05 (−0.11 to 0.01)		
Weekly binge drinking		−0.10 (−0.28 to 0.08)		−0.03 (−0.10 to 0.04)		
Frequent mental distress		0.11 (0.06 to 0.18)		0.13 (0.05 to 0.21)		
Lack of exercise		0.20 (0.14 to 0.26)		0.21 (0.15 to 0.28)		
HIV infection						0.15 (−0.25 to 0.55)

CI = confidence interval.

N = 13,959. AL estimated as a sum of biologic indicators scored positive. Sexual orientation differences estimated by negative binomial regression. Model 1 adjusted for age, race/ethnicity, family income, educational attainment, foreign birth, and survey cycle. Model 2 additionally adjusted for health indicators shown. Model 3 adjusted for HIV infection status, in addition to model 1 confounders.

[a] Referent is exclusive heterosexuals.

men and 71% of lesbians. Similarly, studies suggest that bisexuals have higher proximal stressors associated with concealment of their bisexuality status (81). In addition to experiencing the typical sexual minority stressors associated with heterosexism and homophobia, it has been reported that bisexual individuals also face unique forms of hostility, prejudice, stigma, and discrimination based on attitudes in both the heterosexual and lesbian/gay community (81,85). They are perceived as unable to commit, disloyal, sexually promiscuous, confused about their sexual orientation, and/or immoral or unstable (81) that could compound their stress and AL.

In stark contrast to results among men, we found no sexual orientation differences in AL among women. Compared with exclusively heterosexual women, bisexual women did, however, have higher BMI and lesbian women had lower levels of albumin. The lack of AL differences among women is again consistent with the findings of Juster and colleagues (36). It is noteworthy that secondary analysis of Juster and colleagues' sample (36) revealed that lesbian/bisexual women showed higher dehydroepiandrosterone-sulphate (antagonist of cortisol) and lower low-density lipoprotein ("bad") cholesterol than heterosexual women (86), which denotes a healthier metabolic profile.

The current stress biomarker findings are inconsistent with research indicating that lesbian and bisexual women report poorer overall physical health (87) and evidence more risk factors for disease (83,88) than exclusively heterosexual women. We believe that this inconsistency with other studies showing greater physical health risk (e.g., smoking, alcohol) may be related to metabolic mechanisms that are poorly understood. In the current study and many other AL studies, most biomarkers comprising AL algorithms are related in some way to obesity. As early as adolescence, obesity is more prevalent among sexual minority women (89,90). However, a systemic review of 20 studies concluded that the prevalence of physical health disorders is not higher among these women (91).

There is substantial literature showing that obese sexual minority women can be physiologically fit (92) and emerging literature that they may show dampened inflammatory markers (68). With the exception of an increased risk of asthma, there is some evidence that sexual minority women do not show increased risk for diabetes, hypertension, cardiovascular disease, and most cancers (93). This is despite greater overall risk factors for cardiovascular disease (e.g., smoking, heavy alcohol consumption, and obesity) (94). In an ADD HEALTH analysis, lesbian/bisexual women indeed evidenced greater BMI than heterosexual women; however, they also showed lower levels of C-reactive protein (68) involved in acute phase inflammatory reactions. Interestingly, another study showed that lesbian women experiencing greater discrimination had lower levels of the pro- and anti-inflammatory cytokine interleukin-6 levels (34). Although we did not detect differences in C-reactive protein by sexual orientation, it is possible that unmeasured upstream processes (e.g., cytokines) may have influenced differences among women. Further research that assesses psychosocial characteristics of sexual minority women in relation to stress biomarkers is needed to help solve this puzzle.

Ours is not the only study to not detect within-sex diversity in AL among women. Using a "sex-specific" AL formulation—as opposed to the traditional "all-inclusive" formulation that ignores sex differences in individuals' biomarkers, a recent study found within-sex differences in AL only among working men but not women (66). Independent of sexual orientation, androgynous men reporting both high masculinity (e.g., independent) and high femininity (e.g., sympathetic) evidenced protection against AL, but this difference was not present among women who must juggle more work/home responsibilities and who may not garner the same health benefits of androgynous adaptability that men do. From a cumulative disadvantage perspective, women worldwide experience social inequalities that may affect their AL more than men irrespective of their sexual orientation. The compounding effects of multiple marginalized identities include the pernicious effects of gender inequities (20) that have not been directly assessed in AL studies.

Theoretically, biological sex– and sociocultural gender–based differences influence patterns of physiological stress responsivity (95,96). For instance, women display increased cortisol reactivity when facing social rejection (97), whereas men mount an increased stress response when confronted with social-evaluative threat (98). Taylor and colleagues' evolutionary proposal (99) states that men and women cope differently to stressful situations. Whereas men are more likely to engage in "fight-or-flight" responses, women are more likely to engage in "tend-and-befriend" responses that involve nurturing and affiliation-based behaviors that protect against the demands of pregnancy, nursing, and child care (99). However, how does this theory apply to sexual minority women and men? Within the lifetime of sexual minorities, stress and resilience processes may uniquely influence their stress-related biobehavioral mechanisms.

Our results support thinking that sexual orientation status can be related to within-sex variations in biobehavioral stress responses linked to AL that differs from patterns theorized with heterosexuals in mind. Accordingly, Juster and colleagues (100) showed that cortisol reactivity to a social-evaluative stressor is gender inversed. Specifically, lesbian/bisexual women showed higher cortisol concentrations than heterosexual women, whereas gay/bisexual men showed lower overall cortisol production than heterosexual men in response to the Trier Social Stress Test. Allostatic mechanisms (101) thus span a wide spectrum of response patterns within sex. It follows that stress-related physiological functions will recalibrate to match the needs of unique circumstances over time. Sexual minority status and the psychosocial processes therein may therefore embed biobehavioral patterns in unique ways for each LGB subgroup according to distinct sociocultural pressures (e.g., fitness, diet, partnership, social spaces) to be explored.

Strengths and Limitations

There are several limitations to the current study centered upon the following four areas: (*a*) potential response bias, (*b*) temporality, (*c*) AL formulations, and (*d*) LGB-related psychosocial correlates. First, it is possible that participants' response bias and their willingness to disclose their sexual minority status during the NHANES interview may have confounded the generalizability of our findings. Research suggests that LGB individuals who have "come out" have lower AL compared with their nondisclosed peers (36). Willingness to disclose sexual minority status may be indicative of a well-adjusted, highly resilient subsample of LGB individuals. If so, this could have resulted in a response bias that could explain why gay men show the lowest AL in our study.

Second, the NHANES is a cross-sectional survey. Longitudinal research is the best approach to elucidate the pathways through

which variations in sexual orientation are associated with vulnerability and/or resilience to physiological dysregulation. Other studies have noted that the individual biological pathways through which AL is facilitated differ by race/ethnicity, socio-economic status, and education (102). It is therefore possible that sexual orientation, particularly when combined with race/ethnicity and any of these other variables, may also affect the pathways. Results of our research suggest that it is important to demarcate intersecting statuses (103). Intersectionality recognizes that individuals are members of multiple social groups with diverse societal responses that determine contextual experiences, opportunities, stress exposures, and ultimately health and wellness (104). For example, diurnal cortisol differs by race/ethnicity among sexual minority men (105) and by stigma exposure among transgender men (106). Although power was not sufficient in the current study to properly employ an intersectional approach, future prospective studies could use moderation analyses of race/ethnicity or other identities in interaction with sexual orientation to further nuance the biological footprints of stigmatized identities/statuses.

Third, it is possible that ascribing clinical AL cut-offs without regard for sex differences does not fully capture meaningful associations among women (66). Clinical norms that can identify meaningful biomarker cut-offs to better predict sex-specific disease processes are needed for the advancement of gender medicine. It is also noteworthy that while sex differences exist in individual biomarkers, few AL studies account for these (66). Furthermore in NHANES, individual biomarkers used to calculate AL show factorial unidimensionality; however, subtle variations exist by race/ethnicity (102), speaking potentially to unique experiences of "weathering" among marginalized social groups. Moreover, of the 26 different biomarkers that have been used in 21 NHANES AL studies spanning 1988 to 2010, many do not have population-specific clinical guidelines (107). Lastly, the NHANES does not include neuroendocrine biomarkers such as cortisol. This limitation is not uncommon in the AL literature and does not pose a major limitation given the heterogeneity of biomarkers used in AL studies (15). Nevertheless, it is promising that our population-level findings concord with those of Juster and colleagues (36) who did include neuroendocrine biomarkers in a 21 biomarker AL index.

Fourth, incorporating stress biomarkers may not necessarily provide additional means from which to differentiate AL by sexual orientation without also considering psychosocial variables that can accurately capture individual differences in stress and coping among LGB subgroups. Accordingly, a recent study using a nationally representative sample of young American adults ($n = 1670$) reported no differences in diurnal cortisol as a function of sexual orientation alone. Likewise in ADD HEALTH, sex differences in C-reactive protein and Epstein-Barr virus were reversed among sexual minorities compared with heterosexuals and not explained by known risk factors such as victimization, alcohol and tobacco use, and BMI (108). It may be that stress biomarkers are more strongly correlated to proximal stress processes specific to LGB subgroups (e.g., concealment, disclosure, body image) than to distal stress processes (e.g., victimization, discrimination) that are often assumed to exist by virtue of sexual orientation grouping but that have seldom been actually measured in relation to stress biomarkers. Lastly, the experiences of transgender individuals have received limited attention (109). Emerging research suggest that transgender-specific stressors modulate stress-related biomarkers (106,110) that should be explored in future AL studies.

Despite these limitations, our multisystemic findings complement emerging research showing that LGB individuals may manifest distinct biological profiles as a function of sexual minority stress processes. Specifically, stigma generated by distal processes (e.g., structural stigma) and proximal processes (e.g., "coming out," internalized homophobia) are associated with either upregulation or downregulation of cortisol functioning (36,111,112), a primary mediator of AL. Future research would do well to nuance distal from proximal stress processes central to sexual minority stress theory because the unique experiences of subgroups (e.g., bisexuals) may obscure differences in their unique biological signatures and AL trajectories. Lastly, we encourage disaggregation by sex when assessing sexual orientation subgroups following new NIH recommendations (113). Similar to previously raised concerns (102), if efforts to address health disparities are to be successful studies, such as ours and others who suggest that specific stressors associated with the wear and tear of AL or differences in the pathways that lead to AL, we may need to rethink our clinical intervention and health policies. Launching large-scale untailored interventions may fail to effectively address the way that AL is expressed in some subgroup populations such as male and female LGB members.

CONCLUSIONS

To summarize, our findings indicate that bisexuality among men is associated with elevated physiological dysregulation measured using multisystemic AL indices. By contrast, gay men evidenced the lowest AL, whereas no AL differences were detected among women. These findings underscore the importance of examining stress biomarkers and AL differentially among subgroups of sexual minorities. Additional research is also needed to elucidate the sociocultural pathways that contribute to distinct AL profiles among subgroups of sexual minorities. The impact of minority stressors and unique exposures to stigma experienced by each LGB subgroup differently may drive distinct biobehavioral stress and coping responses that ultimately increase and/or decrease one's risk of developing physical and mental disease.

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