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Using novel methods to examine stress among HIV-positive African American men who have sex with men and women

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Abstract

Biomarker composites (BCs) that objectively quantify psychosocial stress independent of self report could help to identify those at greatest risk for negative health outcomes and elucidate mechanisms of stress-related processes. Here, BCs are examined in the context of existing disease progression among HIV-positive African American men who have sex with men and women (MSMW) with high stress histories, including childhood sexual abuse. Participants ($N = 99$) collected 12-h overnight and morning urine samples for assay of cortisol and catecholamines (primary BC) and neopterin (an indicator of HIV disease progression). Data on cumulative psychosocial trauma history (severity, types, frequency, age at first incident), posttraumatic stress disorder (PTSD) symptoms, sexual risk behaviors, and a secondary BC consisting of routine health indicators (heart rate, blood pressure, body mass index, waist-to-hip ratio) were also collected. Lifetime trauma exposure was highly pervasive and significantly greater among those meeting a standard cutoff for PTSD caseness (24 %). After controlling for HIV factors (neopterin levels and years with disease), PTSD was a significant ($p < .05$) predictor of the primary, but not secondary BC. Those with PTSD also had significantly more sexual partners, sex without a condom, and exchange sex for money or drugs than those without PTSD. Specific trauma characteristics predicted PTSD severity and caseness independently and uniquely in regression models (p 's $< .05-.001$). A primary BC appears sensitive to cumulative trauma burden and PTSD in HIV-positive African American MSMW, providing support for the use of BCs to quantify psychosocial stress and inform novel methods for examining mechanisms of stress influenced health behaviors and disease outcomes in at-risk populations.

Keywords

HIV; African American; Bisexual; Biomarkers of stress; Child sexual abuse

Introduction

Awareness of the links between psychosocial stress, maladaptive health behaviors, and poor mental and physical health has increased in recent years (McEwen & Stellar, 1993; McEwen & Seeman, 1999; Geronimus et al., 2006; Glover et al., 2006; Gleit et al., 2007). However, well-known reliability and validity problems associated with self-report assessments hinder the understanding of these links (Foa et al., 1997; Kaufman & Charney, 2000). Thus, objective biological indicators that quantify psychosocial stress independent of self-report are being sought as a way to: (a) understand mechanisms of these links, and (b) allow for identification of high risk groups *before* negative mental and physical health outcomes arise, or prior to worsening in those with existing compromised health.

The need for new methods to understand the relationship between stress, particularly acute traumatic experiences, and behavior and health is particularly relevant for African Americans who suffer from numerous health disparities (Centers for Disease Control and Prevention [CDC], 2011). Understanding the relationship between these variables within the context of HIV/AIDS among African Americans could serve to promote interventions to address this epidemic. African Americans continue to be disproportionately impacted by HIV/AIDS, as they accounted for 52 % of all diagnoses of HIV infections in 2008 (CDC, 2010), but comprised only 12.9 % of the total population during that time (U.S. Census Bureau, n.d.). Among Blacks, the greatest HIV risk category is male-to-male sexual contact, accounting for 63 % of new infections in 2006 (CDC, 2008). Furthermore, HIV-infected Black men who have sex with men and women (MSMW) are a highly impacted subgroup who may also contribute to the rising rate of new HIV infection for Black women, which is nearly 15 times as high as that of white women and 4 times that of Hispanic/Latina women (Centers for Disease Control and Prevention, 2008). Efforts to address the HIV epidemic have largely focused on behavioral prevention strategies emphasizing HIV education and access to condoms in order to reduce sexual behaviors that increase risk for HIV infection and transmission. However, disproportionate rates of HIV among African American MSMW have continued unabated in spite of these prevention strategies. HIV as an ongoing health crisis highlights the need to identify less known potential contributors of the epidemic and intervention strategies, such as exploring the relationships between acute and chronic stress, mental health, sexual behaviors, and physical health outcomes.

Mental and physical health, and especially sexual health, is complicated by personal, environmental, historical, and institutional factors (Williams et al., 2010). One potentially important but seriously understudied factor is trauma exposure and associated posttraumatic stress disorder (PTSD), a psychiatric illness that may emerge after a person experiences, witnesses, or is confronted with an event involving actual or perceived threat of death, serious injury, or harm to the physical integrity of self or others (American Psychological Association, 2000). For example, death or injury of a family member or close friend among an African American urban middle-school sample was a significant predictor of PTSD for boys (Jenkins et al., 2009). Multiple studies support these findings and show that children who witness or experience acts of community violence are more likely to report symptoms of PTSD (Singer et al., 1995; Buka et al., 2001; Lynch, 2003). Research also indicates that trauma exposure may increase high-risk sexual behaviors (Voisin, 2003).

A history of childhood sexual abuse (CSA), as one form of trauma, is an especially potent predictor of adult generalized emotional distress, anxiety, and PTSD (Whiffen and Benazon-Cathryn, 1997; Maniglio, 2009; Green et al., 2010; Greenfield, 2010; Hornor, 2010). Adult CSA survivors are also at an increased risk for sexual revictimization (Roche et al., 1999; Kalichman et al., 2001; Rumstein-McKean & Hunsley, 2001; Classen et al., 2005; Whiffen

& MacIntosh, 2005; Balsam et al., 2010; Williams et al., 2011). One study found an association between CSA and the initiation of alcohol use and sexual intercourse in youth who had also experienced childhood maltreatment and had witnessed violence (Jones et al., 2010). The combination of substance abuse and sexual risk behaviors is a potent predictor for HIV infection (Sorenson & Copeland, 2000; Volkow et al., 2007; Fisher et al., 2010). Numerous studies have also found that children with sexual abuse histories exhibit more sexualized behaviors than children who have not been abused (Friedrich et al., 2001; Paolucci et al., 2001; Putnam, 2003). Among men, previous studies have linked CSA histories to increased HIV sexual risk behaviors (Briere et al., 1988; Weber et al., 1992; Nelson et al., 1994; Lenderking et al., 1997; Holmes et al., 2005) and emerging research is exploring these links with mental health outcomes (Holmes et al., 2005; Chartier et al., 2009). For example, PTSD with depression was shown to act as both a moderating and mediating variable on the relationship between CSA and the number of lifetime sexual partners (Holmes et al., 2005). Understanding the contribution of trauma and PTSD and links to initiation and chronicity of maladaptive health behaviors among HIV at-risk populations is necessary for the development of holistic health programs, as well as HIV prevention and risk reduction intervention efforts targeting African American MSMW.

Research on biological indicators of psychosocial stress has been heavily influenced by two related theoretical frameworks. First, pre-clinical research in the basic sciences became the foundation for a framework on the neurobiological mechanisms of the stress response. McEwen and Stellar (1993) defined *allostatic load* as the cumulative effect of severe and chronic stress on biological systems. Animal studies identified the primary neurohormonal mediators (cortisol, epinephrine, and norepinephrine) that regulate the normal physiological response to stimuli capable of disrupting homeostasis (i.e., stress). Over time, changes in these primary neurohormonal mediators of a healthy stress response system disrupt secondary “downstream” mediators (e.g., blood pressure and body mass index) and ultimately lead to increases in tertiary outcomes of disease. Geronimus built on the foundational framework of allostatic load in proposing the “weathering” hypothesis to account for health disparities among African Americans as compared to Whites (1992; Geronimus et al., 2006). This hypothesis posits that frequent and/or repeated exposures to acute (traumatic) and chronic stress stemming from racial, socio-cultural, and political inequities contribute to negative health outcomes for African Americans.

There is substantial epidemiological evidence that bio-marker composites (BCs) of primary and secondary mediators, first operationalized by McEwen and Seeman (1999) and subsequently supported in Geronimus’ weathering data (Geronimus et al., 2006), may serve as objective indices for quantifying the impact of stress on physical health risk. In addition, a series of studies in small community samples have tested this hypothesis in relation to acute and chronic stress and PTSD using indicators from the first biomarker study (McEwen & Seeman, 1999) to form BCs (four primary neurohormonal mediators: cortisol and catecholamines-epinephrine, norepinephrine, and dopamine; five secondary mediators: heart rate, systolic and diastolic blood pressure, body mass index, and waist-to-hip ratio). Among a sample of predominantly White, chronically stressed mothers of child cancer survivors (i.e., cancer mothers), BCs were shown to differentiate those with versus those without chronic stress, *and*, among those with chronic stress, differentiate those with and those without PTSD (Glover et al., 2006). BC was associated in a “dose–response” manner with chronic stress and concurrent PTSD. The BC was highest among cancer mothers with PTSD, next highest among cancer mothers without PTSD, and lowest among control mothers of healthy children. BC levels have also been shown to predict disease progression among poor African American and Latina women with HIV (Glover et al., 2009). BC predicted CD4 counts (an indicator of HIV progression) after controlling for age, years since HIV diagnosis, prior CD4 counts, medication adherence, and depression symptoms (Glover

et al., 2009). These peripherally measured primary and secondary biological mediators combined into a composite appear to reflect central neurobiological processes that include structural changes in the brain. In support, BC levels were examined in relation to hippocampal volume measured via brain imaging among healthy, mostly White, chronically stressed mothers of seriously ill children (Glover et al., 2008). After controlling for mother's age and time since the child's medical diagnosis, higher BCs were associated with lower hippocampal volume. This effect was not dependent upon meeting PTSD caseness criteria. Thus, whereas trauma exposure and PTSD may increase risk for higher BCs, chronic stress independent of PTSD is also reflected in BC levels.

Racial/ethnic differences in exposure to traumatic events and the risk for mental (i.e., PTSD and depression) and/or physical health problems have rarely been examined in large scale studies (Roberts et al., 2011). Furthermore, existing studies often neglect factors known to increase the likelihood of developing PTSD, such as cumulative stress burden or specific characteristics of trauma, including severity or timing (during early childhood or later) (Kessler et al., 1995; Bromet et al., 1998; Breslau et al., 1998, 1999, 2004). Only recently has research begun to explore the relationship of trauma and BCs. After controlling for age, childhood family adversity and adult chronic stress burden, trauma characteristics were shown to predict higher BC levels and PTSD symptom severity among a community sample of African American and Latina women (Glover et al., 2010). Specifically, severe (i.e., episodes involving penetration) but not moderate (i.e., fondling and frottage) child sexual abuse was predictive of poor BC and PTSD outcomes with trauma characteristic interactions being different for African American than for Latina women. These findings further indicate that BCs may help to clarify trauma characteristics, cultural factors, and concurrent contextual factors that mediate or moderate stress-health outcomes.

To our knowledge, a BC has not been examined in relation to PTSD and potential associated factors (acute traumatic and chronic psychosocial stress and high risk sexual behaviors) among HIV-positive African American men, generally, or among African American MSMW, specifically. Thus, the overarching aim of the present study is to replicate and extend prior findings that link BCs to PTSD and/or trauma characteristics (severity, type, and developmental timing: 12 years and younger, 13–17 years, and 18 years and older), cumulative psychosocial stress, and sexual risk behaviors in a sample with a progressive disease (HIV) and child sexual abuse histories. Given the potential confounding of disease progression, prescribed medications, and maladaptive health behaviors (e.g., substance use) in this population, it will be important to establish whether links found in other samples can be replicated in a community sample of HIV-positive African American MSMW after controlling for factors known to influence biomarker indicators. This study is a pivotal first step in determining the potential use of BCs to better understand critical acute and chronic stress and behavioral factors that contribute to poor mental and physical health outcomes in racial/ethnic and sexual minority populations who are disproportionately impacted by HIV.

Methods

Sample

A community sample of 117 HIV-positive African American MSMW was recruited from HIV and other service agencies in Los Angeles County using fliers, print advertisements, and face-to-face strategies. Participants were recruited as part of the enhanced sexual health intervention for men (ES-HIM), a randomized controlled intervention whose aims were to decrease sexual risk taking, decrease psychological distress symptoms (i.e., PTSD), and explore associations between outcomes and biomarkers of allostatic load. Data reported here are from the first (baseline) assessment which followed eligibility and informed consent (see below). All participants were HIV-positive, non-gay identifying African American men who

had engaged in unprotected anal and/or vaginal sex with both a male and female partner in the previous 90 days, and who had histories of CSA. CSA was defined as having had an experience, prior to 18 years of age, of unwanted or coerced sexual body contact or any sexual contact with an adult or someone at least 5 years older (Williams et al., 2011).

Procedure overview

Prior to recruitment, Institutional Review Board (IRB) approval for the protection of human subjects in research at the University of California, Los Angeles and a Certificate of Confidentiality (COC) from the National Institutes of Health (NIH) were obtained. As the study focused on a highly sensitive area, child sexual abuse, the IRB approved protocol was especially attentive to issues of confidentiality (i.e., screenings/interviews conducted in private and confidential locations and offices, participant having a clear understanding of the group format of the intervention, etc.). Once screening eligible and providing informed consent, participants were administered a 90-min questionnaire via a laptop computer using audio computer assisted self interview (A-CASI) technology to assess for socio-demographics, trauma experiences, and symptoms of PTSD. A-CASI was used to increase confidentiality and comfort when disclosing sensitive information, such as sex and drug behaviors.

Routine health biomarkers that make up the secondary mediator composite (heart rate, systolic and diastolic blood pressure, body mass index, and waist-to-hip ratio) were assessed during the interview session. Primary neurohormonal mediators (cortisol and catecholamines) and an HIV progression indicator (neopterin) were assessed via urine samples collected within 10 days of the interview and frozen at a clinical laboratory until assayed by batch. Participants completed a urine collection diary including start and end times of each urine collection and a health behavior questionnaire to assess factors occurring within the 24 h preceding urine collection that might influence interpretation of assay results. Participants received \$25 for completing their A-CASI interview and \$10 for completing their urine collections.

Measures

Trauma variables—Childhood sexual abuse was assessed with nine questions from the Revised Wyatt Sex History Questionnaire (WSHQ-R) (Wyatt, 1984), which asks about incidents of fondling, frottage, attempted or completed intercourse, oral sex, and type of penetration prior to the age of 18. WSHQ-R has been found to be reliable with African American men who have sex with men (Williams et al., 2008). A CSA severity index ranging from 0 to 7 was devised by selecting items that strongly correlated with reports of fear (a criterion for PTSD). One risk point was assigned for: (a) penetration, (b) use of force, (c) fear at time of incident, (d) perpetrator being immediate male family member, (e) perpetrator being immediate female family member, (f) having multiple perpetrators, and (g) perpetrator being at least 5 years older than the victim. Scores were categorized as “low severity” (0–3), or “high severity” (4–7). This approach to characterizing CSA is more descriptive than methods that simply assess whether or not CSA was reported (Wyatt, 1985; Wyatt et al., 2004).

The Trauma History Questionnaire (THQ) (Green et al., 1995) was used to assess lifetime exposure to a variety of potentially traumatic events, including crime (i.e., robbery, mugging), natural disasters, accidents involving injury or death, and interpersonal violence (i.e., assault). Items related to physical and sexual abuse during childhood were removed to avoid duplication with the WSHQ-R. Respondents reported if an event was experienced, how many times, and the earliest age at which the event occurred. To examine trauma impact at different developmental stages, each experience was categorized by: (a) age 12

years and younger, (b) 13–17 years, or (c) 18 years and older. The number of unique events was summed for each developmental phase and as a total across all ages. An index of cumulative trauma burden was created for each participant by multiplying the sum of trauma types experienced (1–16) by the frequency of occurrence of each. Sample frequency quartiles for the type $\times$ frequency variable were then used to categorize cumulative trauma load as “low exposure” (<7), “moderate exposure” (7–77), and “pervasive exposure” (>77).

The Posttraumatic Diagnostic Scale (PDS) (Foa et al., 1997) was administered to evaluate participant’s appraisal of the “worst” traumatic event experienced, and to assess the severity of PTSD symptoms as specified in the *Diagnostic and Statistical Manual (DSM-IV-TR)* (American Psychological Association, 2000). Each symptom item was rated on a 4-point Likert scale ranging from 0 (*not at all or only 1 time*) to 3 (*5 or more times a week or almost always*). Participants were instructed to answer questions in relation to the particular index trauma described by them as the “worst.” To evaluate the likelihood of a PTSD diagnosis based on DSM-IV-TR criteria, a cut-off severity score of 18 or more was used for PTSD “caseness” (referred here as PTSD+) (Ehring et al., 2007). Worst traumas were then categorized as sexual (CSA, adult sexual abuse) or non-sexual (including subcategories of non-sexual interpersonal violence, life threatening illness, contextual trauma such as incarceration, accident or natural disaster, and other unspecified events).

Sexual risk taking behaviors—Items of sexual risk behaviors assessed for number of sexual partners and unprotected sex (i.e., sex without a condom) in the past 3 months. Three items assessed for the number of total sexual partners, the number of male sexual partners, and the number of female sexual partners. Items assessing for unprotected oral sex (both performing and receiving), unprotected vaginal sex, and unprotected anal sex (both receptive and insertive) were collapsed into one dichotomized item assessing for unprotected sex. Unprotected sex in exchange for money or drugs was also assessed with one item.

Biomarker composites and health behaviors—The primary neurohormonal BC (cortisol and catecholamines including epinephrine, norepinephrine, and dopamine) and an HIV progression indicator (neopterin) were assessed via urine samples collected at home within 10 days of the interview. Participants collected 12-h overnight urine samples for assay of primary neurohormonal BC indicators in a container with a preservative (0.3 g of sodium metabisulfite), and a single spot urine sample of the first morning void for assay of neopterin (Wirleitner et al., 2005; Siawaya et al., 2007). Supplies including a large urine specimen container, a “spot” container with no preservative, a toilet “hat,” and an “igloo” cooler were provided. Samples were kept in the cooler until transport to the laboratory. After evaluation of total urine volume, aliquots were frozen at -80°C until analyzed via enzyme immunoassay (EIA) for the quantitative determination of neuroendocrine and neopterin concentrations. Safeguards for assuring compliance to urine collection procedures included measuring the volume of urine, amount of creatinine per total volume, and concentration of each biomarker in total and as a function of the creatinine level. Reference ranges for these measurements allowed for identification of potentially contaminated samples. Secondary BC indicators (heart rate, systolic and diastolic blood pressure, body mass index, and waist-to-hip ratio) were also assessed.

A composite of the sum of risk indicators was calculated as in prior studies of BC (McEwen & Seeman, 1999; Glover et al., 2006). The sum score represents the number of indicators for each participant in the top quartile of risk for the total sample. Scores ranged from 0 to 9, reflecting the total possible number of biomarkers in a “high-risk” range. Elevated and blunted neuroendocrine responses to stress have been documented (Lanius et al., 2003, 2006; Glover et al., 2005). Low resting cortisol found among PTSD samples (Glover & Poland, 2002; Yehuda, 2002; Yehuda and McEwen, 2004) have led to the use of a bi-

directional risk strategy for cortisol (i.e., values within the highest or lowest 12.5 % of the total sample) (Seplaki et al., 2005; Gleit et al., 2007). In this study, a bi-directional strategy was applied to cortisol and body mass index, which, if below 18, could indicate severe muscle wasting as seen with AIDS patients.

The Health Behaviors Questionnaire (HBQ) (Glover, 2002) was administered to assess activities in the 24 h prior to urine collection. Questions assessed for the number of caffeinated and alcoholic beverages and cigarettes, quality and amount of aerobic and anaerobic exercise, sleep, meals, use of prescribed and recreational drugs, and illness symptoms. HBQ information was used to exclude urine samples that may have been contaminated by known confounders and to identify potential associations with the biomarker index. Participants also completed a urine collection diary including start and end times of each urine collection.

Data analysis

Descriptive data for continuous (means/SD's) and categorical (prevalence) variables were first examined. Data were categorized to achieve a normal distribution, ensure adequate cell sizes for statistical analyses, or for meaningful interpretation. Specifically, child sexual abuse severity was assessed with an ordinal scale that describes rank order, but not the relative size or degree of difference between the items measured. Therefore, this variable was categorized into "high" versus "low" severity to evaluate the relative impact of severity on outcomes. Cumulative trauma burden was categorized because of extreme range and a non-normal distribution. In such cases, data are appropriately stratified using median splits, quartiles or, other statistically-based approaches (MacCallum et al., 2002). The number of traumas experienced at different developmental stages was a theoretically driven categorization based on previous research examining temporal relationships of CSA and mental health outcomes (Browne & Finkelhor, 1986; Kendall-Tackett et al., 1993; McClellan et al., 1996) and recent trauma specific data from a longitudinal population study which indicates differences in mental health outcomes depending upon timing of childhood adversities (Koenen et al., 2006). A bi-modal, non-normal distribution was found for PTSD severity, with distinct modes falling far below or above the standard cutoff for PTSD caseness (severity score of 18). Given that the aim of the study was to examine the effect of PTSD caseness on the BC, the PTSD variable was categorized by caseness.

Differences on the predictor variables across PTSD status (presence of PTSD vs. absence of PTSD) were examined with Chi-square for categorical variables and analysis of variance for continuous variables. Logistic and linear regression models were used to examine potential demographic and trauma characteristics as predictors of PTSD and to determine their independent contributions. Normality and homogeneity assumptions were tested using a general linear model (GLM). Finally, a series of mixed linear regression models were conducted for each BC outcome (total composite, primary, secondary, and individual primary mediators of cortisol and catecholamines) with age, HIV factors (years since HIV diagnosis, urinary neopterin), health behaviors (tobacco and substance use), and PTSD status entered in invariant order. The recommendations by Kraemer et al. (2008), outlining the MacArthur approach to evaluating mediators and moderators, were followed.

Results

Sample

Of the original sample ($N = 117$), 18 cases were dropped (15 % attrition rate). Of those dropped, 6 cases did not provide urine samples. Of those 12 who provided urine, 7 cases were removed due to biomarker data outside normative ranges (e.g., urine volumes below

200 ml/12 h). Of the remaining 5 cases, HBQ data indicated reports of health behaviors in the past 24 h that could confound interpretation of biomarker values (e.g., use of “crack” or other illicit drugs or very high alcohol use). These 5 cases were also missing demographic and trauma characteristics data. Comparing those cases retained or removed on PTSD symptoms, removed cases ($n = 18$) had significantly higher mean PTSD scores ($M = 16.18$, $SD = 12.7$) than cases retained ($M = 10.04$, $SD = 11.7$) ($F(1,115) = 3.89$, $p = .05$). This left a final sample of 99.

As seen in Table 1, the sample was predominantly middle-aged (mean = 46.6 years, $SD = 8.6$), high school educated (75.8 %), unemployed or unable (disabled) to work (74 %), with the majority of the sample having a total household income of less than or equal to \$12,500. While the sample was behaviorally bisexual, the majority of the sample had never been married (73 %).

Trauma characteristics

All participants had experienced at least one traumatic event (that was *not* CSA) before the age of 4 years, and approximately half of the sample had experienced pervasive lifetime trauma exposure (many types and many times). Of the total sample, 24.2 % ($n = 24$) met all criteria for a PTSD diagnosis (presence of PTSD symptoms). One-third of the overall sample showed a CSA index in the severe range (4–7).

Table 2 provides trauma characteristics and sexual risk behavior data as a function of PTSD status. PTSD+ participants had a significantly greater mean CSA index than those without PTSD ($p < .01$), reflecting a greater percentage of severe CSA (58.3 %) than those without PTSD (24 %). PTSD+ participants had a significantly greater number of trauma exposures types overall and at each developmental stage, and a significantly greater proportion had pervasive exposure based on type $\times$ frequencies of each event relative to non-PTSD participants. Contextual trauma (incarceration, accident, or natural disaster) was the most prevalent type of worst trauma for the total sample. However, of those reporting sexual abuse as the worst trauma experienced ($n = 24$ or 24.2 % of total sample), a significantly greater proportion of PTSD cases reported sexual abuse as the worst trauma experienced (41.7 %) than non-PTSD cases (18.6 %).

Sexual behaviors

Comparison of sexual behaviors by PTSD status indicated that, in the past 3 months, PTSD+ participants had significantly more sexual partners, sex without a condom, and exchange sex for money or drugs (see Table 2).

Linear regression for continuous severity of PTSD and logistic regression predicting the PTSD bi-cut point indicated that each of the trauma variables and each of the sexual behaviors made unique and significant contributions to increasing negative psychological symptom severity or the probability of PTSD caseness (p 's $< .01$). Order of entry had no effect on models. Table 3 shows correlations among key traumatic and chronic stress characteristics, sexual risk behaviors, and PTSD severity.

Biomarkers

None of the demographic variables were significantly associated with biomarker outcomes except age, which was retained as a covariate. Years since HIV diagnosis correlated with age, but was not associated with BCs and was therefore dropped as a covariate. Urine collection duration was examined to control for variations in total minutes collecting urine, but this variable had no effect on BC outcomes and was also dropped. Urinary neopterin ($\mu\text{mol/mol creatinine}$) reflecting HIV progression was not significantly associated with any

BC composite, but was retained, along with age, as a covariate for subsequent analyses involving BC's.

Individual trauma and chronic stress characteristics were not associated with BC levels, perhaps due to the high degree of correlation between these variables, sexual risk behaviors, and PTSD severity (as shown in Table 3). Final mixed linear regression models were used to examine PTSD status as a predictor for primary, secondary, or total BC outcomes. PTSD predicted the primary neurohormonal BC (cortisol, norepinephrine, epinephrine, and dopamine) ($\beta = .58$, $SE = .26$, $p = .03$) and the total (primary plus secondary) BC ($\beta = .80$, $SE = .35$, $p = .03$), but not the secondary composite ($\beta = .23$, $SE = .26$, $p = .36$). Estimated marginal means (after removing effects of covariates) showed that participants with PTSD symptoms had higher total BCs (mean = 2.76, $SE = .31$, CI: 2.15–3.37) compared to those without PTSD symptoms ($M = 1.98$, $SE = .17$, CI: 1.62–2.30) and higher primary BCs (mean = 1.17, $SE = .23$) relative to non-PTSD cases ($M = 0.60$, $SE = .13$). Age was a significant covariate in the model for the secondary ($p < .001$) and total composite ($p < .01$), but not for the primary BC.

Discussion

To our knowledge, this is the first study examining BCs in relation to PTSD and associated factors of chronic and acute psychosocial stress, trauma characteristics, and high risk sexual behaviors among HIV-positive African American MSMW. Findings indicate that the identified trauma characteristics and risky sexual behaviors all uniquely and independently predicted PTSD severity and caseness (above recommended cut-off for clinically meaningful symptoms) (Ehring et al., 2007) and that PTSD in turn, predicted the primary and total (primary plus secondary) BCs. These results were independent of HIV progression effects controlled via statistical inclusion of urinary neopterin.

This study may also be the first to compare primary (i.e., central neurohormones) versus secondary (i.e., downstream effects, such as hypertension) BCs in a sample with a tertiary disease (HIV infection). That PTSD was only associated with primary and the total composites, but not the secondary composite underscores the need to routinely analyze each separately. Consequences of HIV infection (i.e., body wasting) may possibly alter secondary mediators in complex ways, making them unreliable indicators of health risk in HIV-infected samples (Christeff et al., 2002). Alternatively, the allostatic load framework posits that extreme chronic and acute stress-related dysregulation begins with primary neurohormonal mediators. When profound stress begins in early childhood, as was the case in this sample, perhaps secondary mediators play a smaller role in long term negative sequelae.

The allostatic load framework does not speak to the temporal order of biomarker dysregulation versus PTSD in predicting poor outcomes following profound stress. Unlike the earlier study among African American and Latina women (Glover et al., 2010), stress characteristics were not directly related to BC's here, but were strongly associated with PTSD, which in turn, predicted the primary and total (primary plus secondary) BCs. BC's were also unrelated to sexual risk behaviors directly. Such findings suggest the primacy of PTSD over BC's; profound stress leads to PTSD, which then precipitates increased sexual risk behaviors and biomarker dysregulation. However, such an interpretation should be viewed with caution. Limitations of this study include a small sample size, cross-sectional design, the absence of a control group with no CSA or other profound childhood or adult stress, and the potential confounds of substance abuse and HIV infection. Prospective longitudinal studies are needed to assess the temporal order of profound stress, PTSD and

biomarker dysregulation, in predicting sexual risk behaviors and poor health outcomes over time.

Nonetheless, findings that the biomarker composite here differentiated those with and without PTSD among HIV-positive African American males replicate and extend prior work with community samples of HIV-negative, mostly White women with chronic stress (Glover et al., 2006) and poor African American and Latina women with and without HIV infection (Glover et al., 2009, 2010). Data confirm links between PTSD and: (a) child sexual abuse severity; (b) perceiving sexual abuse as the worst of all traumas experienced; (c) cumulative trauma burden, including type and frequency; and (d) risky sexual behaviors, including increased number of sexual partners, sex without a condom, and exchange sex for money or drugs. The importance of differentiating the type, severity, and timing of child abuse on adult mental health confirms previous research (Kessler et al., 1997; Green et al., 2010). Echoing recent epidemiological findings of the impact of childhood trauma on adult mental health (Green et al., 2010), the total number of trauma types exposed to before the age of 12 was a strong independent predictor of PTSD. Furthermore, total trauma types during the teenage years and as an adult were each additional independent predictors of PTSD, as was an index of pervasiveness of trauma (total types $\times$ frequency of occurrence). Together, these data provide evidence for the impact of cumulative trauma type and frequency at every developmental stage on adult psychological health.

Researchers have begun to explore the role of appraisal of experiences as traumatic versus non-traumatic in the prediction of psychological distress (Holmes, 2008; Bal et al., 2009). These efforts are aimed at understanding the meaning of the experience to the individual and whether appraisal influences risk behaviors or mental health outcomes. Few of the CSA survivors in our study reported CSA as the worst trauma experienced. Nonetheless, 41.7 % of those with PTSD perceived sexual traumas (CSA and adult) as the “worst” trauma experienced. Such data may suggest that the impact of subsequent adult sexual trauma on mental health in CSA survivors is particularly virulent, perhaps serving as a reminder of the earlier CSA experiences and therefore compounding the severity of PTSD symptoms. Also, only 20 % of the total sample of HIV-infected men reported illness as the worst trauma experienced. That almost 75 % of these men had moderate to pervasive cumulative trauma exposure and 100 % experienced at least one traumatic event prior to the age of four, suggests the sheer number of trauma types and frequencies of each may have influenced the appraisal process, with the most recent traumatic events more likely than earlier ones to be appraised as the worst. An accurate account of the temporal order of each trauma type in relation to the worst trauma was not possible here, but this potential recent temporal effect should be explored in future studies.

African American MSMW are at high risk for HIV infection and to transmitting the virus once infected. The risky sexual behavior links to PTSD, CSA severity, and cumulative trauma burden found among our sample replicate and extend scattered individual studies in various populations (Follette et al., 1996; Messman-Moore et al., 2000). This population has many potential sources of acute and chronic stress, as evidenced by their triple minority status, being HIV-positive, and racial/ethnic and sexual minorities, and by their cumulative stress burden. The effects of PTSD status were found even after controlling for age and neopterin-assessed HIV progression. Therefore, the primary BC appears to reflect a unique and objective indicator of PTSD even among those with a tertiary disease.

The utility of this objective indicator may provide novel alternative strategies for behavioral interventions to impact the HIV epidemic among African American MSMW. Primary BCs collected through urine may be an efficient and cost-effective screening method along with psychosocial assessments to identify those at highest risk for PTSD. Alternatively,

biomarkers may be useful instead of psychosocial assessment instruments, which are known to be burdensome and influenced by a host of conscious and unconscious reporter biases (Foa et al., 1997; Kaufman & Charney, 2000). Also, BCs may provide a more objective method of intervention effectiveness than psychosocial assessments alone. The strong relationships between PTSD, risky sexual behaviors, and a variety of indicators of acute and chronic stress, including specific characteristics (type, severity, and timing) indicate that interventions may need to directly address the mechanisms that govern how past and current stress alter risky sexual behaviors. For example, previous research supports that high-risk sexual behaviors are related to the use of sex as a stress reducer (McKusick et al., 1985; Coates et al., 1989; Folkman et al., 1992). Exploring changes in coping strategies in relation to changes in BCs over time may provide new insights into the active components of behavioral change strategies. The application of BCs along with self-report instruments could better identify and follow those individuals at-risk for poor sexual, physical, and mental health outcomes.

Conclusion

This study provides the first evidence for a link between PTSD and a BC of primary neurohormonal mediators of the stress system in an HIV-positive sample of African American MSMW with histories of chronic and acute stress, including child sexual abuse. The PTSD-primary mediators link was independent of HIV infection progression, suggesting BCs may ultimately be used to objectively quantify mental and physical health risk even among those already diagnosed with disease. These data also support the examination of trauma variables in predicting overall health of HIV-positive African American MSMW and understanding the potential mediating factors that impact sexual behavior change.

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Table 1

Demographic characteristics

Demographic	% of sample
Education ^a	
Less than high school	29.3
High school diploma or GED	46.5
Vocational/technical school degree	14.1
Associate, bachelor or graduate degree	10.1
Employment	
Unable to work (disabled) or unemployed	74.0
Employed part- or full-time or in school	20.0
Retired/homemaker	6.0
Income (total annual income)	
Less than or equal to \$12,500	63.0
More than \$12,500	37.0
Marital status	
Never married	73.0
Married	4.0
Divorced/separated	21.0
Widowed	2.0

^a As defined by highest educational degree obtained

Table 2

Trauma characteristics

Mean (SD) or % of group	PTSD absent <i>n</i> = 75	PTSD present <i>n</i> = 24	<i>p</i> value
<i>Trauma characteristics</i>			
CSA severity ^a	2.5 (1.6)	3.5 (1.8)	**
Number of trauma exposure types ^b			
Before the age of 12	0.9 (1.6)	2.1 (2.4)	**
During age 13–17	0.4 (0.8)	1.2 (1.4)	***
As an adult	3.3 (3.0)	5.6 (3.1)	***
Total (all ages)	4.7 (4.0)	8.9 (3.3)	***
Cumulative trauma burden ^c			
Pervasive exposure	37.3	87.5	***
Moderate	28.0	12.5	
Low exposure	34.7	0.0	
Trauma type appraised as “worst” ^d			
Sexual			
Childhood sexual abuse	3.9	25.0	
Sexual assault as an adult	14.3	16.7	
Non-sexual			
Contextual trauma ^e	45.5	41.7	
Life-threatening illness	24.7	8.3	
Interpersonal violence ^f	5.2	4.2	
Other	6.4	4.1	
Overall sexual/(non-sexual)	18.2 (81.8)	41.7 (58.3)	**
<i>Sexual risk behaviors^g</i>			
Total number of sexual partners	2.84 (1.4)	4.21 (4.0)	**
Male partners	1.53 (0.9)	2.38 (2.6)	*
Female partners	1.31 (1.2)	1.83 (1.7)	*
Sex without a condom—no/(yes)	36.0 (64.0)	16.7 (83.3)	*
Sex for money—no	87.5	65.0	**
Yes—1–3 times	10.4	15.0	
Yes—4 or more times	2.1	20.0	

% of group values are in italics

* $p < .05$;

** $p < .01$;

*** $p < .001$

^aFrom WSHQ-R⁴⁰; CSA severity included: (1) at least 5 years older; (2) penetration; (3) force; (4) fear at the time; (5) perpetrator was immediate family member; (6) multiple perpetrators within immediate family; (7) multiple perpetrators of both male and female; range was 0–7

^bFrom THQ⁴⁴; excluded child sexual abuse, child physical abuse and child neglect; range was 0–16 possible traumas

^cSum type × sum frequency; <7 = low, 8–77 = moderate, 77–200+ = pervasive

^dFrom PDS⁴⁵

^eContextual trauma includes incarceration, accident or natural disaster

^fNon-sexual interpersonal violence only

^gIn the past 3 months

Table 3

Correlations among predictors

Pearson correlations	PTSD Symptom severity	CSA Severity index	Number of trauma types			Cumulative trauma Low, moderate, pervasive	Worst trauma Nonsexual/sexual	Sexual behaviors	
			Before age 12	Age 13–17	Adult			# of sex partners	Sex for money
PTSD severity	–	.30***	.29**	.37***	.41***	.52***	.27***	.27***	.20*
CSA severity		–	.14	.10	.25***	.28**	.35***	.14	.28**
# Types before age 12			–	.37***	.04	.57***	.05	.06	.18
# Types age 13–17				–	.16	.53***	–.14	.07	.13
# Types as adult					–	.82***	.02	.15	.18
# of types Total						–	.004	.15	.25**
Cumulative burden							–.02	.14	.17
Worst trauma							–	.04	.13
# Sex partners								–	.33**

*
 $p < .05$;

**
 $p < .01$;

 $p < .001$