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Stress Measured by Allostatic Load Score Varies by Reason for Immigration: the Africans in America Study

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Abstract

Objective—Reason for immigration as a biological stress has not been studied in Africans. Our goal was to determine in African immigrants, if biological stress measured by allostatic load score (ALS) varies by reason for immigration.

Methods—Using an ALS which had been previously developed with National Health and Nutrition Examination Survey (NHANES) data to assess stress due to racism and nativity, ALS was calculated in 85 African immigrants (67% male, age 42±10y). For confirmation, we tested five additional ALS also built from NHANES.

Results—The two reasons for immigration which consistently had the lowest ALS were family reunification and lottery winner for self and immediate family. The other reasons for immigration such as: study, asylum/refugee and work had higher ALS. As reasons for immigration with the lowest ALS promoted family unity, they were combined (Group-1) and the Africans who came for other reasons were combined (Group-2). ALS in Group-1 vs. Group-2 was: 1.96±1.40 vs. 2.94±1.87, $P=0.03$.

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Conflict of Interest Statement

Author Jean N. Utumatwishima declares he has no conflict of interest.

Author Rafeal L. Baker, Jr declares he has no conflict of interest.

Author Brianna A. Bingham declares she has no conflict of interest.

Author Stephanie T. Chung declares she has no conflict of interest.

Author David Berrigan declares he has no conflict of interest.

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Ethical Responsibilities of Authors

This manuscript has not been submitted to more than one journal for simultaneous consideration and has not been published previously. No data have been fabricated or manipulated to support our conclusions. No data, text, or theories by others are presented as if they were the author's own.

Consent to submit has been received explicitly from all co-authors. Authors whose names appear on the submission have contributed sufficiently to the scientific work and therefore share collective responsibility and accountability for the results.

Conclusions—Biological stress varies by reason for immigration and appears to be mitigated by maintaining family unity. Overall, reason for immigration is important biographical data likely to influence health.

Keywords

Stress; Allostatic Load Score; Immigrants; African Immigrants; Biomarkers

Introduction

The number of sub-Saharan Africans immigrating to the United States has doubled every decade since 1970[1]. Therefore in 2010, 4% of the foreign-born population in the United States were African immigrants[1]. Immigrants face many challenges, but Africans in the United States also have to cope with the immediate transition to membership in a minority population[2,3]. To understand the impact of immigration on the health of Africans, the factors which contribute to the stress of immigration must be identified and the biological consequences measured. Such research is highly relevant to global health as the number of immigrants increases worldwide.

Immigration related factors which promote stress and have been previously studied in Africans include: age of immigration, duration of stay in the United States and family structure[2–4]. Absent from this list is the reason for immigration. We are unaware of any studies which have examined the impact of reason for immigration on the health of African adulthood immigrants. The reasons African adults come to the United States are numerous and include: family reunification, lottery winner for self and immediate family, to-be-married, study, asylum/refugee and work. We postulate that the reason for immigration may modulate both the degree of stress and the behavior response (ie. assimilation behaviors) and lead to dissimilar effects on health.

To measure the biological consequences of stress, the allostatic load score (ALS) is frequently used[5]. ALS is based on the principle that repeated activation of the hypothalamic-pituitary-axis and the sympathetic-adrenal-medullary axis leads to a high output of hormones and an adverse effect on health in three domains: cardiovascular, metabolic and immune[5,6]. However, there is no consensus on how to construct the ALS equation in terms of either the biomarkers to include or how to define a high-risk threshold for the chosen biomarkers[7,5]. Investigators typically respond to this dilemma by creating a study-specific ALS[7,5]. We took a different route and chose an ALS equation developed with National Health and Nutrition Examination Survey (NHANES) data previously published by Geronimus et al. and subsequently used by Kaestner et al. and others[8–10].

This equation was relevant to African immigrants for two reasons; first, these investigators examined in Mexican-Americans and African-Americans issues relevant to the African immigrant experience such as: racism, nativity, sexism, aging and income; and second, high-risk thresholds for each biomarker were cohort-specific and not dependent on clinical guidelines[8,9]. For each biomarker, the NHANES cohort was divided into quartiles and according to the variable, the threshold at the highest or lowest quartile was used. The alternative procedure to determine high-risk thresholds is to use clinical guidelines for each

variable, but this may not be optimal for African descent populations[7]. Most clinical guidelines were established in cohorts such as Framingham and values considered high-risk in whites might not apply to blacks[11,12]. This is particularly true in the lipid arena [13–16].

In our previous work with African immigrants, we used the ALS equation of Geronimus et al, [4] and found that older age of immigration and increased duration of stay was associated with increased ALS. In this analyses we focus on reason for immigration in Africans who came to the United States as adults, meaning 18 years of age or older rather than as minors. Childhood immigrants do not come to the United States for work or study or to-be-married. More likely they are accompanying their legal guardian such as a parent or they are being adopted. In short, child and adulthood immigrants do not enter the United States for the same reasons and are exposed to different stressors. We again use the ALS presented by Geronimus et al. as our reference equation, but we also test five additional ALS equations which were identified as part of formal literature review of ALS (Table 1)[7]. There were two reasons why these five equations were chosen[17,2,18,19,8,20]. First, they, too, calculated ALS from NHANES datasets[7]. Second, their high-risk thresholds for biomarkers were based on quartile analyses rather than clinical guidelines[7].

Our primary goal was to determine in African immigrants if biological stress, as defined by six different ALS formulations, would reveal any consistent pattern according to reason for immigration. Our secondary aims were to evaluate the association between assimilation behavior and reason for immigration. In addition, we evaluated which lipid parameter in the ALS was most appropriate for African descent populations.

Methods

The Africans in America study is an on-going cross-sectional study designed to evaluate factors which affect the cardiometabolic health of African immigrants[4,21–23]. Recruitment is achieved by newspaper advertisement, previous participant referral, flyers, community gatherings and the NIH website. The NIDDK Institutional Review Board approved the study (NCT00001853). Prior to participation informed written consent is obtained for each participant.

The enrollment process begins with a telephone interview. To qualify, the caller must self-identify as an African who is healthy and currently living in the Washington, DC area. The place of birth for the enrollee must be sub-Saharan Africa. In addition, the caller must report that both parents are black Africans who were also born in sub-Saharan Africa.

For this study, metabolic data was available in 261 African immigrants living in the Washington, DC area (male: 69%, age: 40±10 (mean±SD), range 21–64y, BMI 27.8±4.5, range 18.2–42.4 kg/m², African region of origin: West 53%, Central 21%, East 26%). Data on reason for immigration at time of initial entry in to the United States was available for the 100 most recently enrolled immigrants, 85 of whom were adulthood immigrants. Fifteen were childhood immigrants. This analyses focuses on the 85 adulthood immigrants (West

58%, Central 19%, East 22%). The six reasons for immigration were: family reunification, lottery for self and immediate family, to-be-married, study, asylum/refugee and work.

Clinical Studies

Two outpatient visits were conducted at the NIH Clinical Research Center in Bethesda, Maryland.

At Visit 1, a history is taken. Reason for immigration is asked at the first visit. In addition, a physical examination and EKG are performed. Routine blood tests are done to confirm the absence of anemia, kidney, liver and thyroid disease.

For Visit 2, after a 12h fast, the participant arrives at the Clinical Center at 7AM and rests quietly for 20 minutes. Then blood pressure (BP) and pulse are obtained three times approximately five minutes apart. The mean of the second and third readings are recorded. Next, waist circumference (WC) is measured at the superior border of the iliac crest. Hip circumference is measured at the maximal protuberance of the buttocks. Then fasting blood is drawn for A1C, lipids, hsCRP, homocysteine and albumin levels. This is followed by a 2h OGTT (Trutol 75; Custom Laboratories, Baltimore, MD)[24].

Determination of Allostatic Load Score

The calculation of ALS requires identification of high-risk thresholds for each of the 14 biomarkers used in the 6 ALS equations (Table 1) (Supplement Figure 1)[17,2,18,19,8,20]. The biomarkers were in three categories: cardiovascular (systolic BP, diastolic BP, pulse, cholesterol, triglyceride (TG), high density lipoprotein (HDL), homocysteine), metabolic (BMI, WC, waist-to-hip ratio (WHR), A1C, albumin, eGFR) and immune (high sensitivity C-reactive protein (hsCRP)). To identify thresholds for the high-risk quartile for each biomarker, the larger cohort of 261 African immigrants was divided into sex-specific quartiles. High-risk was defined as a value above the 75th percentile for all biomarkers except HDL-C, albumin, eGFR which used the value below the 25th percentile. Then each biomarker is turned into a dichotomous variable with one point given if the biomarker is in the high-risk range and 0 if not. Use of antihypertensive medication led to the assignment of the high-risk category for BP. The higher the ALS, the greater the physiologic dysfunction.

Analytic measures

Cholesterol, triglyceride, HDL, homocysteine, albumin, creatinine, and hsCRP were measured in plasma (Roche Cobas 6000 analyzer, Roche Diagnostics, Indianapolis, IN). A1C values were determined by HPLC using a National Glycohemoglobin Standardization Program (NGSP)-certified instrument, known as D10 which was made by BioRad Laboratories (Hercules, CA).

Statistics

Unless otherwise stated, data are presented as mean $\pm$ SD. *P*-values ≤ 0.05 were considered significant. As appropriate, group comparisons were made using unpaired t-tests, and Chi-square tests. Analyses were performed with STATA14.0 (College Station, Texas).

RESULTS

Reasons for immigration were: study (n=25), work (n=17), family reunification (n=15), asylum/refugee (n=15), lottery winner for self and immediate family (n=8) and to-be-married (n=5), and. Rank ordering of lowest to highest ALS, revealed in all 6 equations, family reunification and lottery had the lowest 2 allostatic load scores. The other 4 reasons for immigration always ranked above those 2 reasons, even though there were internal shifts. For example, in terms of ALS to-be-married ranked third in 5 out of the 6 equations and fourth in 1 equation (Figure 1 and Supplement Figure 2).

Based on how the ALS data aggregated, we divided the cohort into 2 groups:

Group 1 (n=23): family reunification and lottery for self and immediate family

Group 2 (n=62): study, work, asylum/refugee, to-be-married

It was decided to call Group 1 the “group which maintains family unity” because both of those reasons include existing marriage (spouses previously married in Africa) as well as sibling to sibling and parent to child relationships. Immigration lottery winners are allowed to bring their immediate family including existing spouse with them to the United States (Diversity Immigrant Visa Program, DV-2016). In contrast, Group 2 with reasons such as study and work did not require family bonds.

The “to-be-married” group was included Group 2 because in all 6 equations the ALS ranked higher than family reunification and lottery. In short, to establish a new marriage with one partner traveling to the United States from Africa was viewed differently from an existing marriage because the pattern of ALS was different.

Percent male, current age, age of immigration and years in the United States of the participants were: 67%, 42±10y, 31±9y and 11±9 year, respectively (Table 2). These variables did not vary by group (Table 2).

Social and Behavioral Variables

All of the Africans who were smokers were in Group 2. In addition, alcohol intake, defined by greater than one drink/week, tended to be higher in Group 2 than Group 1 (Table 2).

Income was higher in Group 1 than Group 2 (Table 2). In fact, 65% of immigrants in Group 1 had a median income greater than \$45,000 compared to 40% of Group 2, $P=0.04$.

Educational attainment, rate of marriage and health care insurance coverage did not differ by group.

Allostatic Load Score Equations

Equations 1, 2 and 3, revealed that ALS was significantly lower in Group 1 than Group 2 (P -values of 0.03, <0.01, 0.02, respectively) (Table 3) (Figure 1). For Equations 4 and 5, the difference between Group 1 and Group 2 approached significance (P -values were 0.08 and 0.09, respectively) (Supplement Figure 2). For Equation 6 the difference between Group 1 and Group 2 was not significant ($P=0.21$) (Supplement Figure 2).

Biomarker Pattern

Of the 14 biomarkers included in the six equations, none of the mean values were significantly different by group (Table 2) suggesting an absence of a dominant single biomarker. Nonetheless, due to well-known race differences in HDL and TG levels[16], we compared the relative importance of HDL and TG in the six ALS equations. We found that no equation used both HDL and TG. But, four equations used HDL (Equations 2, 3, 4 and 6) and two used TG (Equations 1 and 5)(Table 1). When Equations 1 and 5 were modified such that HDL replaced TG, the significant difference between Groups 1 and Group 2 increased (Table 3). For Equation 1 the significant difference between Group 1 and Group 2 was observed to go from $P=0.03$ to $P=0.01$. For Equation 5 the significance changed from $P=0.09$ to $P=0.06$ (Table 3).

Equation 6 included HDL as a biomarker. However, this equation had only 8 biomarkers compared to 9 or 10 for the other equations[2]. In addition, Equation 6 did not include a biomarker for either body size or degree of glycemia. When Equation 6 was modified by increasing the number of biomarkers to 10 by including both BMI as a marker of body size and A1C as indicator of glycemia, significance for the difference in ALS between groups changed from $P=0.21$ to $P=0.04$ (Table 3).

DISCUSSION

In this study, which is the first examination of the relationship between stress and reasons why Africans immigrate to the United States, we found in all six equations the two reasons for immigration which maintained family unity always remained numerically in the lowest two ALS positions (Figure 1). Therefore, coming to the United States for reasons that ensure family unity is associated with less biological stress than coming for to-be-married, study, asylum/refugee and work. Certainly, this finding makes commonsense, but our evaluation was driven by objectively collected biomarkers using previously published ALS equations.

In a related finding, we report that unhealthy assimilation behaviors as defined by alcohol consumption and smoking prevalence, tended to be lower in the family unity group. This could be secondary to the positive effect of being surrounded by family.

In addition, we found that HDL is superior to TG as a biomarker in African immigrants of stress-induced physiologic dysfunction. This finding was possible because we considered both the genetic and metabolic background of the population under study.

Smoking, Alcohol Consumption and Income

It is generally believed that in becoming acculturated to life in the United States, immigrants from the world-over increase their smoking and alcohol intake[2,9,3]. This has become known as unhealthy assimilation behaviors[9]. To our knowledge, previous studies have not examined whether there was a link between these behaviors and reason for immigration.

In an earlier publication with the Africans in America cohort, we reported that Africans were different from other immigrant groups in regard to the development of assimilation behaviors[4]. Even with increased duration of stay in the United States, self-reported use of

cigarettes and alcohol by African immigrants remained low. In this study, we bring a new dimension to the perspective of assimilation behaviors in African immigrants. We found that the rate of smoking in African immigrants was low (only 6%), but all the African immigrants who were smokers were in Group 2 and came to the United States for reasons other than family unity. Similarly, alcohol intake tended to be higher in the non-family unity group. We cannot say whether these two behaviors adversely affected biomarkers and drove up the ALS in Group 2 or if these behaviors were response to stress (ie. a form of self-medication). Either way, we propose that going forward assimilation behaviors should be examined within the context of reason for immigration.

We also observed that income was significantly higher in the family unity group. In studies of African-Americans and in our earlier study of African immigrants, we found that higher income did not mitigate stress level and lower ALS. Therefore, in the current study we postulate that income, itself, is not likely to account for the difference in ALS between the two groups. However, higher income in the family unity group may be a key factor in providing the opportunity for family reunification.

Number and Choice of Biomarkers

To appreciate the implications of a high ALS, it is necessary to review how ALS is constructed and analyzed. Two key issues in regard to ALS are the number of biomarkers and the choice of biomarkers.

As ALS represents the overall physiologic response to frequent activation of the HPA and SMA axes, ALS is determined by the collective effect of the frequency of multiple biomarkers in the high-risk quartile rather than the absolute value of any specific biomarker[5,6]. Our evaluation confirms this principle. The t-test comparisons showed no difference between groups in any of the 14 biomarkers, even though the difference in ALS between Groups 1 and 2 were significant in three of the ALS equations and approached significance in two of the ALS equations. We found that the degree of difference in ALS between Group 1 and Group 2 varied depending on whether TG or HDL was included as a biomarker.

Together, elevated TG and low HDL are known as the dyslipidemia of insulin resistance[15]. In insulin-resistant whites, elevated TG and low HDL levels almost always occur together and both are effective markers of risk for cardiometabolic disease. In populations of African descent, insulin resistance is characterized by low HDL but normal TG levels. Both metabolic and genetic factors can explain why elevated TG levels are uncommon in insulin-resistant individuals of African descent. Compared to whites, African descent populations have higher LPL levels, lower apoC-III concentrations and less VAT[25–27]. Furthermore, African-Americans are an admixed population and every 10% increase in African ancestry is associated with a 1% decrease in TG levels[28]. The practical consequence of these metabolic and genetic characteristics of TG levels in African descent populations means that screening tests which rely on TG levels to predict insulin resistance in African descent populations perform poorly [14,29,16,30–32]. In contrast, low HDL levels in African descent populations are a marker of insulin resistance and an indicator of risk for both heart disease and diabetes[31].

On this basis, we postulated that detection of differences between Group 1 and Group 2 would be enhanced in the two equations which used TG if HDL replaced TG. When Equation 1 was modified such that HDL replaced TG, the P-value declined from 0.03 to 0.01 (Table 3). For Equation 5 the P-value for the difference between the two groups declined from 0.09 to 0.06. In short, when choosing (or constructing) an ALS equation, the metabolic and genetic background of the population under evaluation needs to be considered[11].

We recognize that Equation 6 used HDL rather than TG but unlike the other three equations which used HDL as a biomarker, no difference between the 2 groups was detected ($P=0.21$). However, Equation 6 had eight biomarkers. The other equations had either nine or ten biomarkers. The challenge with Equation 6 relates not to the choice of lipid but to the absence of a biomarker for either body size or glycemia. When two key metabolic biomarkers were added to the equation, specifically, BMI and A1C, the difference in ALS between the two groups declined from 0.21 to 0.04 (Table 3).

Strengths and Limitations

A major strength of the study is that the consecutively enrolled Africans were willing to share both their reason for immigration and their date of entry. However, there are four major limitations. First, this is a convenience sample of African immigrants who were in the country legally. The second major issue is the sample size. With only 85 participants we could not separate the immigrants into six groups by reason for immigration but had to accept the post hoc division of the group into two. Third, as this is a cross-sectional study, we do not know whether the group with the higher ALS will have worse long term health outcomes. However, the MacArthur prospective studies of successful aging have demonstrated that higher ALS predicts a higher rate of all-cause mortality[33]. In addition, a prospective study of ALS conducted in Taiwan revealed that for each 1 point increase in ALS, mortality increased[34]. For every ALS equation in our study, ALS was ~1 unit higher in Group 2 than Group 1. Fourth, ALS was evaluated relative to self-reported reason of immigration at time of original entry into the United States. Current immigration status, specifically type of visa, green card or citizenship was not addressed.

Public Health Implications

We have demonstrated that reason for immigration is important biographical data which may influence both health and behavior. African immigrants who came to the United States for reasons that maintained family unity, had a lower level of stress measured by ALS than immigrants who came for other reasons. Hence, adding reason for immigration should be considered in both epidemiologic research and medical histories.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Allostatic Load Score by reason of immigration according to three equations. Each equation plotted numerically from lowest to highest ALS. Mean values for family reunification and lottery (Group 1) and the other reasons (Group 2) are presented with *P*-value comparisons. A: Equation 1 (Reference 8), B: Equation 2 (Reference 17), C: Equation 3 (Reference 20).

Table 1

Biomarkers included in the Allostatic Load Score Equations

Equation	Number of biomarkers	Biomarkers	Differences from Equation 1
Equation 1 Reference 8	10	CV: SBP, DBP, cholesterol, TG, homocysteine Metabolic: BMI, A1C, albumin, eGFR Immune: hsCRP	
Equation 2 Reference 17	10	CV: SBP, DBP, HDL, pulse, cholesterol, homocysteine Metabolic: BMI, A1C, Albumin Immune: hsCRP	+ HDL + Pulse – TG – eGFR
Equation 3 Reference 20	9	CV: SBP, DBP, cholesterol, HDL Metabolic: BMI, Albumin, A1C, WC Immune: hsCRP	+ HDL + WC – HCYST – TG – eGFR
Equation 4 Reference 19	9	CV: SBP, DBP, cholesterol, HDL, pulse Metabolic: Albumin, WHR, A1C Immune: hsCRP	+ HDL + Pulse + WHR – TG – BMI – HCYST – eGFR
Equation 5 Reference 18	10	CV: SBP, DBP, TG, cholesterol, homocysteine Metabolic: A1C, eGFR, albumin, WHR Immune: hsCRP	+ WHR – BMI
Equation 6 Reference 2	8	CV: SBP, DBP, pulse, cholesterol, HDL-C Metabolic: eGFR, albumin Immune: hsCRP	+ Pulse + HDL – TG – HCYST – BMI – A1C

Table 2

Demographics and Characteristics of Participants

Parameter (mean±SD)	Total Group (n=85)	Group 1 ^a (n=23)	Group 2 ^b (n=62)	P-value
Male	67%	65%	68%	0.83
Current Age (y)	42±10	40±9	43±10	0.35
Age at Immigration (y)	31±9	30±10	32±8	0.20
Years in US (y)	11±9	10±7	11±10	0.54
Income (< 45k)	47%	65%	40%	0.04
Cigarette Smoking	6%	0%	8%	0.16
Alcohol (>1 drink/week)	24%	13%	27%	0.17
College Graduate	82%	78%	84%	0.55
Married	59%	61%	58%	0.82
Health Insurance	78%	78%	77%	0.93
BP-systolic (mmHg)	122±16	121±17	122±15	0.77
BP-diastolic (mmHg)	74±9	74±12	74±8	0.71
Pulse (beats/min)	67±10	68±9	67±10	0.94
Cholesterol (mg/dL)	169±33	161±30	173±33	0.13
TG (mg/dL)	79±37	70±26	82±40	0.21
HDL (mg/dL)	56±18	57±13	56±19	0.78
Homocysteine (μmol/L)	8.5±3.2	7.5±2.2	8.8±3.4	0.08
BMI (kg/m ²)	27.8±4.2	26.8±3.5	28.1±4.4	0.20
WC (cm)	91±11	89±9	91±12	0.43
WHR	1.89±0.09	0.89±0.06	0.88±0.09	0.68
A1C (%)	5.4±0.5	5.3±0.4	5.4±0.5	0.13
eGFR (mL/min/1.73 m ²)	104±21	106±19	103±22	0.59
Albumin (g/dL)	4.1±0.2	4.1±0.3	4.1±0.2	0.67
hsCRP (mg/L)	1.38±1.81	0.97±0.88	1.53±2.03	0.20

^a Reasons for immigration: family reunification and lottery for self & immediate family

^b Reasons for immigration: to-be-married, study, asylum/refugee, work

Table 3

Allostatic Load Scores

Parameter (mean±SD)	Total Group (n=85)	Group 1 ^a (n=23)	Group 2 ^b (n=62)	P-value
Equation 1 (Reference 8)	2.67±1.80	1.96±1.36	2.94±1.87	0.03
Equation 2 (Reference 17)	2.48±1.55	1.70±1.33	2.77±1.53	<0.01
Equation 3 (Reference 20)	2.06±1.49	1.43±1.27	2.29±1.51	0.02
Equation 4 (Reference 19)	2.20±1.46	1.74±1.60	2.37±1.38	0.08
Equation 5 (Reference 18)	2.77±1.84	2.22±1.68	2.97±1.86	0.09
Equation 6 (Reference 2)	1.92±1.36	1.61±1.50	2.03±1.31	0.21
Modified Equation 1 ^c	2.58±1.71	1.83±1.47	2.86±1.73	0.01
Modified Equation 5 ^c	2.68±1.76	2.09±1.76	2.90±1.73	0.06
Modified Equation 6 ^d	2.44±1.64	1.83±1.53	2.66±1.64	0.04

^a Reasons for immigration: family reunification and lottery for self and immediate family

^b Reasons for immigration: to-be-married, study, asylum/refugee, work

^c ALS after HDL substituted for TG

^d ALS after BMI and AIC added