Prospective Predictors of Blood Pressure among African American Men Living with HIV

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Abstract

Little is known about the predictors of blood pressure (BP) among African American men living with HIV. We examined whether age and body mass index (BMI) are associated with higher blood pressure (BP) and whether being married and muscular endurance are associated with lower BP among African American men living with HIV. Second, we examined whether being married moderated the effects of the other predictors on BP. Finally, we examined whether BMI mediated the relationship between muscular endurance and BP. This article is a prospective secondary analysis of data from a randomized controlled trial of a health-promotion intervention for African American men living with HIV. We measured the participants' BP pre-intervention and three, six, and 12 months post-intervention. Generalized estimating equations linear regression analyses examined whether marital status, age, BMI, and muscular endurance predicted BP post-intervention, adjusting for pre-intervention BP and the intervention. Older age, higher BMI, and lower muscular endurance predicted higher BP post-intervention, adjusting for the intervention and baseline BP. Although marital status did not predict post-intervention BP, it moderated the negative effect of higher BMI. The positive relation of BMI to BP was weaker among married men than unmarried men. Muscular endurance had an indirect impact on BP mediated through BMI. Public health efforts targeting older African American men with HIV should focus on increasing muscular endurance in this population to lower BMI as a strategy to reduce cardiovascular disease risk in this population.

Keywords: male, African American, risk factors, HIV infections, blood pressure, hypertension

Introduction

African American men living with HIV have high rates of hypertension, a risk factor for cardiovascular disease (CVD) morbidity and mortality, including heart attacks and strokes [1]. Antiretroviral therapy has prolonged the life span of people living with HIV [2]. People's risk of developing hypertension increases as they live longer with HIV [3, 4]. Longitudinal analyses confirm that older age is associated with incident hypertension among people living with HIV [5]. Some evidence suggests that the prevalence of hypertension in people living with HIV may exceed the prevalence among their HIV-negative counterparts [6, 7].

Besides older age, excess weight is a significant cause of hypertension [8, 9]. A large longitudinal study on people living with HIV found that higher body mass index (BMI) was associated with incident hypertension [5]. An analysis of patients with HIV found that hypertension and obesity were highly prevalent, particularly among African Americans [10]. Accordingly, there have been calls for weight assessment and management programs to be part of routine HIV clinical care [10, 11].

Physical fitness is one of the most significant predictors of individual future morbidity and mortality [12, 13, 14]. Along with cardiorespiratory fitness, muscular fitness is an essential component of physical fitness, contributing to the prevention of non-communicable diseases [15, 16, 17]. Indeed, guidelines for health-enhancing physical activity include muscle-strengthening activity [18, 19, 20]. Muscular fitness includes muscular strength, muscular endurance, and muscular power [21, 22].

Although each aspect of muscular fitness has health benefits, the relationship of muscular strength to health has been traditionally the most frequently studied [23]. A review concluded that muscular strength reduces the risk of all-cause and cancer mortality and is inversely

associated with hypertension risk [23] and risk of hypertension mortality [24]. A recent prospective cohort study suggests BMI may mediate the relationship between cardiorespiratory fitness and blood pressure (BP) [25].

Several studies suggest that marriage may confer health benefits, including a reduced risk of hypertension. A study of patients with diabetes mellitus found that those who were married were less likely to have hypertension [26]. Similarly, married coronary disease patients had a reduced prevalence of hypertension than their unmarried counterparts [27].

Some studies suggest that the benefits of marriage may be more significant among men than women. A recent cohort study found that never married men had a higher risk of developing hypertension than married men, but never married women had a lower risk of hypertension than married women [28]. Moreover, married cancer patients are less likely to present with metastatic disease, more likely to receive definitive therapy, and less likely to die from their cancer, with men experiencing more benefits than women [29, 30]. Evidence also indicates that marriage, especially for men, is associated with a lower risk of cardiovascular disease, cancer, and all-cause mortality [31, 32, 33]. Being married, then, may confer several health benefits, including reducing the risk of high BP, particularly in men. It may be that, like social support [30], marriage may buffer the effects of factors that increase BP or potentiate those that reduce BP. To our knowledge, studies have not explored this intriguing possibility.

This article reports a study examining factors that predict BP among African American men living with HIV. We examined whether age and BMI were associated with higher BP and whether being married and having greater muscular endurance were associated with lower BP. Second, we examined whether being married moderated the effects of the other predictors on BP.

Finally, we examined whether BMI mediated the relationship between muscular endurance and BP.

Methods

This article reports a secondary prospective analysis of African American men living with HIV who participated in a health-promotion intervention randomized controlled trial. Institutional Review Board #8 at the University of Pennsylvania approved the study. Written informed consent was required to participate.

Men aged 40 or older self-identifying as Black or African American and receiving antiretroviral therapy for HIV were eligible. Men who a) displayed a BP ≥ 180/110 mm Hg, b) participated in a health-promotion intervention trial targeting PA, diet, or prostate or colon cancer screening in the past 12 months, or c) lacked a mailing address or planned to move beyond a reasonable distance from the study within the next 18 months were excluded.

We recruited the participants from a database of people living with HIV who consented to be contacted for research and through referrals from local HIV service providers and AIDS Service Organizations and ads in a local newspaper and social media sites, including Facebook, Twitter, and Craig's list. We enrolled the trial participants over 35 months beginning in January 2015, completing all data collection by December 2018.

The participants were randomly assigned to a three-session health promotion intervention to increase physical activity or a one-session health awareness control intervention. The present article draws on the baseline, 3-, 6-, and 12-month post-intervention data from the trial. We included in the analysis sample participants with BP data at baseline and at least one post-intervention follow-up session. Prospective analyses adjusted for intervention condition.

Measures. Self-report data were collected using audio-computer assisted self-interviewing [34, 35, 36]. Marital status is a binary variable where 1 = married and 2 = not married.

Research coordinators measured the participants' BP (in mm H-g) on their left arm three times at 1-min intervals, and we used the mean of the three readings for the analyses. BMI was determined based on measurement of the participants' weight and height. The research coordinators used a calibrated scale to measure the participants' weight, to the nearest 0.1 kg, with the participants wearing light clothing without shoes. Using a standard height indicator, they measured height to the nearest 0.1 cm. We calculated BMI as weight (kilograms) divided by height in meters squared.

We operationalized muscular endurance as the mean of 1-min push-up test and 1-min sit-up test performance, the number of pushups or sit-ups the participants did in one minute [37, 38, 39, 40]. The combined push-up and sit-ups test scores have been linked to reduced Framingham coronary heart disease risk scores [39]. A recent study found that push-ups predict 1-RM bench press performance, suggesting they are a marker of upper body muscle strength [40].

Statistical analyses. We used two generalized estimating equations (GEE) linear regression models to examine the relationship of baseline marital status, age, BMI, and fitness to BP post-intervention, considering systolic BP and diastolic BP as repeated measures. The models specified an "identity" link and used an independent working correlation matrix and robust standard errors. Model 1 examined each of the predictors individually, adjusting for pre-intervention BP, post-intervention time (i.e., three categories representing three, six, and 12-months post-intervention), BP type (systolic versus diastolic), and the intervention condition. Model 2 examined the four predictors adjusting for pre-intervention BP, post-intervention time,

BP type, and intervention condition. We report estimated regression coefficients (*b*) with corresponding 95% confidence intervals.

We examined whether BMI mediated the relation of muscular endurance to post-intervention BP using a product-of-coefficients approach in a GEE framework. The α path represented the relationship of muscular endurance to BMI, adjusting for intervention, baseline BP, age, and marital status. The β path represented the relationship of BMI to BP post-intervention, adjusting for intervention, post-intervention time, BP type, baseline BP, age, and marital status. An $\alpha\beta$ product significantly greater than zero would indicate an indirect or mediated effect of muscular endurance on BP through BMI.

We tested whether marital status moderated [41] the relationships of the predictors to BP over time by adding the Marital Status x Predictor two-way interactions to Model 2. We also assessed whether the results differed for systolic BP and diastolic BP by testing the interactions between type of BP and the predictors. Where the interaction is significant, we report the results separately for systolic BP and diastolic BP. We analyzed the data with SAS 9.4 and used the $p < .05$ two-tailed significance criterion.

Results

As shown in Table 1, of the 302 participants enrolled in the trial, the 289 (96%) in the analysis sample do not differ on the enumerated characteristics from the 13 (4%) excluded. The men ranged in age from 40 to 88 (mean = 53.89; SD = 7.25), 11% were married, and 76% had at least high school education. Their median and modal monthly income were $400 to $850, and 96% had health insurance.

The analysis of Model 1, presented in Table 2, revealed that older age, higher BMI, and lower muscular endurance predicted higher BP post-intervention, adjusting for baseline BP, time

of post-intervention assessment, BP type, and the intervention. There were significant interactions of BP type with age, b = 0.20, 95% CI 0.08, 0.33, p = .001, and muscle endurance, b = -0.13, 95% CI -0.23, -0.03, p = .012. The relation of age to higher blood pressure was stronger for systolic BP, b = 0.26, 95% CI 0.09, 0.42, than diastolic BP, b = 0.04, 95% CI -0.09, 0.18. The relationship of muscle endurance to lower blood pressure was also stronger for systolic BP, b = -0.25, 95% CI -0.43, -0.08, than diastolic BP b = -0.14, 95% CI -0.26, -0.01.

The analysis of Model 2 showed that BMI predicted post-intervention BP, adjusting for the Model 1 covariates and all of the predictors. Age, p = .074, marital status, p = .114, and muscular endurance, p = .060, were not significant. The age interaction with BP type was significant, b = 0.20, 95% CI 0.07, 0.33, p = .003. The relation of age to higher blood pressure was stronger for systolic BP, b = 0.22, 95% CI 0.05, 0.41, than diastolic BP, b = 0.02, 95% CI -0.12, 0.16. No other interaction with BP type was significant.

The marital status moderator analyses revealed a significant interaction between marital status and BMI, b = -0.60, 95% CI -1.10, -0.11, p = .017. BMI was more strongly associated with higher BP among unmarried men, 0.29, 95% CI 0.09, 0.49, than married men, -0.34, 95% CI -0.80, 0.13.

Mediation analysis revealed that muscular endurance had an indirect effect on BP mediated through BMI. First, regarding the association between the independent variable and the mediator (α path), we found that the relationship of muscular endurance to BMI was statistically significant (b = -0.18, 95% CI [-0.25, -0.10], $p < .001$), adjusting for age, marital status, intervention condition, BP at the baseline, and BP type (systolic and diastolic). People with greater muscle endurance were likely to have lower BMI. Second, considering the association between the mediator and the outcome variable (β path), we found that BMI was significantly

associated with BP (b = 0.26, 95% CI [0.06, 0.47], p = .010), adjusting for age, marital status, intervention condition, measurement time, blood pressure at the baseline, and blood pressure type. This result shows that people with higher BP had higher BMI. Lastly, the bootstrapping based on 2,000 replicates showed that the asymmetric confidence interval (ACL) of the $\alpha\beta$ product did not include 0 ($\alpha\beta$ = -0.05, 95% ACI [-0.09, -0.01]), indicating the significant mediated effect of muscular endurance on BP through BMI.

Discussion

This study's primary purpose was to examine the relationships of age, marital status, BMI, and muscular endurance to higher BP among African American men living with HIV. The secondary goals were to examine whether marital status moderated the effects of age, BMI, and muscular endurance and whether BMI mediated the relationship of muscular endurance to higher blood BP.

Consistent with our hypothesis, the results revealed that higher age and BMI were associated with more elevated BP, and greater muscular endurance was associated with lower BP. Although marital status did not predict post-intervention blood pressure, marital status moderated BMI's harmful impact on BP. Thus, being married was protective such that higher BMI was less strongly associated with higher BP among married men than among unmarried. There was also evidence consistent with the view that BMI mediated the relationship of muscular endurance to reduced BP.

Our findings are consonant with studies showing that age and BMI are associated with high blood pressure [3, 4, 8, 9]. Few studies have examined age and BMI in relation to high BP among people living with HIV [5]. This study is the first investigating these relationships in African American men living with HIV, to our knowledge.

Although many studies have found that married men have reduced morbidity and mortality than unmarried men, the evidence on whether being married is associated with lower resting blood pressure has been inconsistent. Recent work suggests that being married may be related to more significant dips in nocturnal BP and lower nocturnal BP [42]. We found that being married was associated with nonsignificant lower resting blood pressure. Nevertheless, we did identify a potentially salubrious influence of marriage. Namely, being married appeared to buffer the effects of BMI such that higher BMI was less likely to result in more elevated BP in married compared with unmarried men. This study is the first to examine a potentially buffering effect of marriage in affecting BP among men living with HIV.

A novel feature of this study is its focus on the mediation of predictors of blood pressure over time. The study highlights the role of BMI as a mediator in the prediction of BP. It suggests targeting BMI and that one way to target it would be to focus on another modifiable variable, muscular endurance.

This study's limitations include the relatively small sample. More participants would have increased statistical power to test relationships. The study is also limited because the participants were African American men 40 and older living with HIV enrolled in a health promotion intervention trial. The results may not generalize beyond this population.

Conclusion

African American men living with HIV are at high risk for hypertension, a risk factor for CVD morbidity and mortality. This study, utilizing a prospective design and objective measures, suggests that older age, higher BMI, and low muscular endurance are significant risk factors for high BP in African American men aged 40 and older living with HIV. Accordingly, public health efforts should prioritize intervening with African American men living with HIV who are older,

have a high BMI, and display low levels of muscular endurance to reduce their risk of CVD. Interventions should aim to increase muscular endurance in this population to lower BMI to reduce CVD risk in this population.

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Table 1. Characteristics of participants included in and excluded from the sample, African American men living with HIV, Philadelphia, PA

Characteristic, Mean (SD) or N (%)	Included (N = 289)	Excluded (N = 13)	*p*
Health-promotion intervention	144 (50)	8 (62)	.409
Age	53.89 (7.25)	53.77 (7.32)	.954
Married	33 (11)	0 (0)	.197
Education level			.943
0. No formal school	7 (2)		
1. Less than high school diploma or GED	63 (22)	4 (31)	
2. High school diploma or GED	116 (40)	3 (23)	
3. Some college or a 2-year degree	82 (28)	6 (46)	
4. 4-year college degree	11 (4)		
5. Post-graduate work	10 (3)		
Income level (monthly)			.388
1. Less than $400	51 (18)	5 (38)	
2. $400 to $850	141 (49)	3 (23)	
3. $851 to $1,650	71 (25)	5 (38)	
4. $1,651 to $2,500	18 (6)		
5. $2,501 to $3,300	6 (2)		
6. $3,301 to $4,100			
7. $4,101 or more	2 (1)		
Employed	49 (17)	1 (8)	.379
Health insurance	277 (96)	12 (92)	.538
Body mass index	28.11 (5.89)	30.09 (6.97)	.238
Muscular endurance	11.86 (8.70)	16.46 (10.72)	.067
Systolic blood pressure	131.79 (18.28)	131.19 (19.00)	.912
Diastolic blood pressure	83.52 (12.16)	86.47 (14.05)	.413

Note. The *p* (significance probability) is from χ^2 tests for binary variables, Wilcoxon rank-sum tests for education and income, and Student's *t* tests for all other variables.

Table 2. Estimated effect (*b*) and 95% confidence interval (CI) from generalized estimating equations models of the relation of baseline predictors to post-intervention blood pressure, African American men living with HIV, Philadelphia, PA, N = 289

Predictor	Model 1 *b* (95% CI)	*p*	Model 2 *b* (95% CI)	*p*
Age	0.16 (0.02, 0.29)	.027	0.13 (-0.01, 0.28)	.074
Married	-2.64 (-6.32, 1.03)	.159	-2.98 (-6.68, 0.72)	.114
BMI	0.26 (0.05, 0.47)	.013	0.21 (0.02, 0.40)	.029
Muscle endurance	-0.19 (-0.34, -0.05)	.008	-0.14 (-.28, 0.01)	.060

Note. Model 1 is adjusted for the intervention, baseline of the criterion, and post-intervention assessment time (three, six, and 12 months post-intervention). Model 2 includes the Model 1 adjustments and tests the predictors simultaneously, thus adjusting for each predictor.

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