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The association of changes in behavioral risk factors for stroke with changes in blood pressure

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Abstract

Background—High blood pressure is the leading stroke risk factor. Data on the association of physical activity, fruit and vegetable consumption and dietary sodium with hypertension are lacking in Hispanic communities. In the current report we provide data on the association of changes in these stroke behavioral risk factors with blood pressure change.

Methods—Participants were recruited from participating Catholic churches in Nueces County, Texas. Blood pressure was measured, and self-reported validated scales of fruit and vegetable consumption, dietary sodium and physical activity were collected at baseline and 12 months. Linear mixed models were used to examine the associations between tertiles of improvement in the three behavior outcomes with blood pressure change, adjusted for demographic characteristics. The association of the binary measure of at least 5 mm Hg diastolic blood pressure or 10 mm Hg systolic blood pressure reduction and behavior change was estimated with multilevel logistic regression models.

Results—Of 586 participants, 66% were female, 82% Mexican American, and mean age was 54 years. High compared with low change in physical activity was significantly associated with diastolic blood pressure change ($p=0.022$), and high compared with low change in fruit and vegetable intake was significantly associated with systolic blood pressure change ($p=0.032$). For the binary changes in diastolic blood pressure or systolic blood pressure there was a borderline association of physical activity ($p=0.054$); all other variables were not associated ($p>0.10$).

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Conclusions—Physical activity and fruit and vegetable consumption are potential stroke prevention targets in predominantly Mexican American populations.

Keywords

Hispanic; hypertension; stroke prevention; physical activity; sodium; fruit and vegetable

INTRODUCTION

Studies suggest that physical activity and dietary behaviors are important for blood pressure control. The Stroke Health and Risk Education (SHARE) study was a community-based behavioral intervention trial aimed at stroke prevention by targeting behavioral risk factors for hypertension. The study included predominantly Mexican Americans (MAs) and partnered with the Diocese of Corpus Christi, Texas, USA, to deliver the intervention. The study demonstrated modest improvement in the primary outcomes of fruit and vegetable (F&V) intake and sodium reduction but not physical activity (PA) in those randomized to receive the intervention compared to the control group. There were no changes in the secondary outcome of blood pressure change in the intervention compared with the control group¹.

Multi-ethnic studies are important to address stroke disparities. MAs have increased stroke risk compared with non Hispanic whites (NHWs)², and hypertension is the number one risk factor for stroke³. Addressing stroke risk in MAs logically suggests the importance of blood pressure control. Indeed, while Hispanics are underrepresented in hypertension control trials, the available data suggest that blood pressure control is worse in Hispanics compared with NHWs and African Americans⁴.

In the current manuscript we determine the association of changes in PA, F&V intake and sodium reduction with blood pressure change in the SHARE study population. There are clinical trial and observational data that suggest that increasing F&V intake^{5–7} and PA^{8,9} are associated with blood pressure reduction. Although more controversial, there is also evidence that reducing sodium is associated with lower blood pressure^{10–12} with recent society calls for governments to mandate sodium restriction¹³. The 2013 Guideline on Lifestyle Management to Reduce Cardiovascular Risk suggests increases in F&V intake, PA, and reductions in dietary sodium¹⁴. The current study provides an opportunity to determine if changes in these three behavioral risk factors are indeed associated with changes in blood pressure in a predominantly MA community. It also affords the opportunity to view whether results suggested by guidelines are applicable to “real world” communities without academic medical centers.

METHODS

SHARE was an NIH funded cluster-randomized, parallel group, church-based, multi-component behavioral intervention trial designed to reduce stroke risk in MAs and NHWs living in Corpus Christi, Texas, USA (Clinical Trial Registration—URL: <http://www.clinicaltrials.gov>. Unique identifier: NCT01378780). The comparison group received skin cancer awareness materials. We adopted F&V consumption, PA and dietary sodium as

co-equal primary outcomes and included SBP as a secondary measure and DBP as an exploratory measure. The association of the primary outcome measure with changes in SBP and DBP is presented here. SHARE methods were previously reported¹⁵. Since blood pressure was not influenced by the intervention, we present results here combined for intervention and control groups and will not review the intervention methods.

Study Subjects

Subjects were recruited as family or friend pairs from Catholic Churches in Nueces County, Texas. Subjects provided demographic information including race, ethnicity and educational attainment. Approximately 95% of the residents of Nueces County, Texas reside in the City of Corpus Christi which is an urban location of approximately 350,000 people on the Southern Texas Gulf Coast. Approximately 2/3 of the population are MA and 1/3 NHW. The MA population are stable, non-immigrant and long-time residents of the community¹⁶. Subjects were eligible if they were >18 years of age and NHW or MA members of a participating church, spoke English or Spanish, and were permanent residents of the Corpus Christi area. This project was approved by the University of Michigan IRB and written informed consent was obtained from all participants.

Measurements

Subjects participated in a baseline and 12 month assessment in-home by a trained study coordinator. In both meetings dietary data were obtained by using the Block 2005 Food Frequency Questionnaire modified for a six-month reference period and to include foods preferred by Hispanics. Dietary data were analyzed commercially¹⁷. Total average daily sodium intake (mg) was obtained from considering all foods. Average total daily cups of fruit intake, including fruit juices were used to calculate fruit consumption. Vegetable estimates included average total daily cups of vegetables including legumes but not potatoes. Standard procedures were used to eliminate dietary records that appeared invalid¹⁸ and to eliminate outliers for individual measures. The Stanford 7-day recall physical activity questionnaire was used to measure PA. PA was classified as light, moderate, and hard and very hard intensity, and we recorded the total MET minutes for the last seven days for each category¹⁹. Records where total PA estimates were outside the range 13,230–46,620 METS-min for the week were considered invalid reports. Since moderate or harder intensity, but not light PA are considered beneficial, we used the weekly amount of moderate or higher intensity PA as the measure of PA in this study. Blood pressure, the primary outcome measure in the current analysis was measured by an automated device (OMRON-HEM-780)²⁰. The standard protocol was to seat subjects quietly for a minimum of 5 min; then measure blood pressure in the right arm (unless medically contraindicated) with the arm supported at the mid-sternal level. We took 3 consecutive readings and averaged the last two²¹. The difference in blood pressure change between the two visits was computed and used as the outcome in regression models. A binary variable of blood pressure improvement was also created to reflect a conservative clinically meaningful change: a participant was categorized as improving BP if his/her systolic blood pressure was reduced by 10mmHg or more, or if his/her diastolic blood pressure was reduced by 5mmHg or more. We chose this binary measure since it is proven to reduce stroke and coronary heart disease with well-

defined risk reduction estimates from clinical trials²². We also recorded the number of blood pressure medications subjects were taking at baseline and 12 months.

Statistical Analysis

Descriptive statistics were computed for all variables. Because participants were nested in participant pairs and churches, multilevel linear regression models²³ were used to compute the mean change and standard errors of the change within categories of baseline and demographic variables, and to assess the crude association between tertiles of change in the three behaviors and blood pressure as well as the association between change in the number of medications taken and blood pressure. Random intercepts for participant pairs and for churches were used to account for the within pair and within church correlations in changes in BP. Crude and adjusted associations between change in behavior and blood pressure change were also estimated from multilevel models. The models were adjusted for age (in quartiles), sex, race/ethnicity (MA vs NHW) and education (in categories: <HS, HS, some college, college or more). The association of the binary measure of blood pressure improvement and behavior change was estimated with multilevel logistic regression models. SAS version 9.3 was used for all analyses.

RESULTS

Of the 760 consented individuals, 624 attended both baseline and 12 month follow-up visits. Of these, 2 were excluded due to missing blood pressure data at one or both visits, and 36 additional were excluded because they had diet or PA reports that were missing or considered invalid at one or both visits. This analysis includes the data available on the remaining 586 (77%) subjects.

Table 1 provides demographic characteristics of the sample, the baseline data for subjects DBP and SBP change, and percent of the sample who improved SBP by at least 10mmHg or improved DBP by at least 5mmHg. The population for this analysis included 82% MAs. At baseline, median (interquartile range [IQR]) systolic blood pressure was 123.5 (112.5, 135.5) and 124 (111.5, 136.5) at 12 months; and diastolic blood pressure was 79 (72.5, 85.0) at baseline and 77.5 (71.5, 85.0) at 12 months. Tertiles of change for increased PA were: increases of 900 METS or more (high), less than 900 METS but more than 600 METS (medium), and 600 METS or less (low). Tertiles of change for F & V intake were: 1/3 cup increase or more (high), less than 1/3 cup increase but not more than 1/2 cup decrease (medium), and 1/2 cup decrease or more decrease (low). Tertile changes in sodium were: 635 mg or more (high), less than 635 mg reduction and less than 145 mg increase (medium), and 145 mg or more increase (low).

At baseline, the median (IQR) in fruit and vegetable consumption was 2.2 cups/day (1.5, 3.2), while sodium consumption was 3,165 mg/day (2,144, 3,834). PA had a median of 1320 MET-min per week, with IQR 600, 3300. The median (IQR) change in these behaviors were: -0.10 (-0.8 to 0.6) fruit and vegetable cups per day; -242 (-878 to 314) mg/per day of sodium; and 120 (-960, 1380) MET-min per week. Behaviors were categorized into tertiles as follows. Tertiles of change for increased PA were: increases of 900 MET-minutes per week or more (high), less than 900 MET-min increases but no more than 600 METS

decrease (medium), and 600 METS or greater decrease (low). Tertiles of change for F & V intake were: 1/3 cup increase or more (high), less than 1/3 cup increase but not more than 1/2 cup decrease (medium), and 1/2 cup decrease or greater decrease (low). Tertile changes in sodium were: 635 mg reduction or more (high), less than 635 mg reduction but less than 145 mg increase (medium), and 145 mg or more increase (low).

Table 2 provides baseline categories and change in PA, F&V and sodium intake. The greatest decreases in blood pressure were seen in the groups who increased F&V intake and increased PA. Tests of the hypothesis that at least one tertile was different from the others showed an association of PA and DBP ($p=0.019$) and a trend for an association of F&V and SBP ($p=0.069$); all others were not associated ($p>0.15$). Comparing high change with low change in PA was significantly associated with DBP reduction ($p=0.022$), and high compared with low change in F&V intake was significantly associated with SBP reduction ($p=0.032$) (Fig 1). Figure 2 provides the data for the association of changes in PA, F&V intake and sodium consumption with binary changes in DBP (5 mm Hg) and/or SBP (10 mm Hg). Overall, there was a borderline association of the greatest increase in PA with binary reductions in DBP or SBP ($p=0.054$); all others were not associated ($p>0.10$).

There was no significant association between changes in the number of BP medications participants were taking from baseline to 12 months and change in blood pressure, so this particular measure does not account for the changes noted in blood pressure over time.

DISCUSSION

This analysis suggests that increases in PA and F&V intake are associated with beneficial reductions in some of the SBP, DBP and binary blood pressure measures used in this study over a period of 12 months. Overall the changes in blood pressure were modest. However, even small changes in blood pressure such as those seen in this study are associated with substantial stroke risk reduction²⁴, and our data suggest that PA improvement may be important in meeting these threshold blood pressure changes.

Previous studies have demonstrated that lifestyle changes are associated with blood pressure reduction. In a cross-sectional analysis of 2,046 patients from the Dietary Approaches to Stop Hypertension (DASH) study those who were most adherent to the DASH diet had the lowest blood pressures²⁵. Further, baseline high intake of F&V was associated with lower rates of developing hypertension after 13 years of follow-up in a cohort study of middle and older age women, although the effect was small⁷. In a recent trial, a tailored, hypertension stage-matched intervention including diet, exercise and medication was found to significantly reduce SBP (by 3.5 mmHg) and control hypertension compared to usual care²⁶.

The 2013 AHA/ACC Guideline on Lifestyle Management to Reduce Cardiovascular Risk provides Class I, Level of Evidence A recommendations to decrease blood pressure by emphasizing consumption of F&V and decreasing sodium intake¹⁴. It gives a Class IIa, Level of Evidence A recommendation for PA. The current work supports these recommendations for PA and F&V consumption, but not sodium intake. Indeed, the link between sodium intake and blood pressure has remained controversial¹⁰. The changes in

sodium consumption, a difficult behavior to modify, in this study were modest and potentially not large enough to influence blood pressure. Further, a recent report suggests a non-linear association of sodium with blood pressure with the greatest effect found in hypertensive patients. There may have been too few hypertensive patients in the current study to demonstrate an effect²⁷.

This study had several strengths including enrolling subjects in a community without an academic medical center. The community also has a high proportion of non-immigrant MAs; a microcosm of what the U.S. will look like in coming decades. MAs are the largest subgroup of Hispanic Americans, the United States' largest minority population, and one that is rapidly growing and aging²⁸. The study also had several weaknesses including using self-report measures of F&V intake, sodium consumption and PA. The study was exploratory and did not correct for multiple comparisons. Conversely, the study was not powered to examine the association of changes in behavioral measures with changes in blood pressure so we may have missed a true association. It is possible that those who were able to change PA and F&V were also able to make other changes to their lifestyle and medical regimen that were associated with blood pressure improvements. We used a crude measure of medication change, alteration in the number of blood pressure medications; it is possible that including changes in dosage may have explained more of the association of blood pressure change. This work came from a single community and generalization to other communities and other race/ethnic populations should be done cautiously. The primary purpose of SHARE was not to determine the association of behavioral risk factors with hypertension so the results found here must be considered hypothesis generating.

In summary, this study found an association of increases in PA with reductions of DBP and increases of F&V intake with reductions in SBP. There were no associations of changes in sodium intake with changes in either DBP or SBP. Further studies in predominantly Hispanic populations should continue to investigate if increases in F&V intake and PA may lead to hypertension prevention and treatment.

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Fig 1.

Average change and 95% CI in DBP (1a) and SBP (1b) for each tertile of behavior improvement, estimated from 3 separate models (one for each behavior change), adjusted for demographics. * indicates $P < 0.05$ for the comparison to low improvement.

Fig 2. Probability of reducing SBP by at least 10mmHg or DBP by at least 5mmHg. Results from 3 separate models (one for each behavior change), adjusted for demographics. ** $p < 0.025$ for comparing to low behavior change.

Table 1

Demographics and blood pressure.

	N(%)	DBP change (mmHg)	SBP change (mmHg)	Improve SBP or DBP (%)
Age				
<43	123 (21)	0.2 (−1.8, 2.1)	−1.3 (−4.8, 2.2)	37
43–52	151 (26)	−0.6 (−2.3, 1.2)	0.1 (−3.2, 3.4)	41
53–63	148 (25)	−0.9 (−2.7, 0.9)	−2.2 (−5.4, 1.1)	46
>63	164 (28)	−0.1 (−1.8, 1.6)	1.8 (−1.4, 5.0)	33
Sex				
Male	201 (34)	−0.5 (−2.0, 0.9)	−0.7 (−3.5, 2.2)	41
Female	385 (66)	−0.3 (−1.4, 0.8)	−0.1 (−2.4, 2.2)	38
Ethnicity				
MA	480 (82)	−0.3 (−1.3, 0.7)	−0.3 (−2.5, 1.9)	37
NHW	102 (18)	−0.8 (−2.9, 1.3)	−0.4 (−4.3, 3.5)	50
Education				
<HS	71 (12)	−0.4 (−3.0, 2.2)	2.9 (−1.5, 7.4)	28
HS	167 (28)	−0.2 (−1.8, 1.5)	−0.7 (−3.7, 2.3)	41
Some College or Trade school	212 (36)	−0.9 (−2.4, 0.6)	−1.8 (−4.6, 0.9)	40
College or more	136 (23)	0.2 (−1.6, 2.1)	0.8 (−2.6, 4.1)	42
Randomized to intervention				
Yes	294 (50)	−0.7 (−2.0, 0.6)	−0.7 (−3.8, 2.4)	40
No	292 (50)	−0.0 (−1.3, 1.3)	0.2 (−3.0, 3.3)	39

Frequencies (%) of baseline characteristics, estimate and 95%CI for the mean change in blood pressure over 12 months, and percent who improve SBP by at least 10mmHg or improve DBP by 5mmHg or more.

Table 2

Tertiles of behavior change and associated blood pressure change.

	N(%)	DBP change (mmHg)	SBP change (mmHg)	Improved SBP or DBP (%)
PA improvement				
High	198 (34)	-2.1 (-3.6, -0.6)	-1.8 (-4.7, 1.1)	46
Med	195 (33)	0.6 (-1.0, 2.1)	0.8 (-2.1, 3.7)	37
Low	191 (33)	0.4 (-1.1, 1.9)	0.1 (-2.8, 3.0)	34
Fruit and Veg Improvement				
High	195 (34)	-1.5 (-3.0, 0.1)	-1.9 (-4.8, 0.9)	43
Med	186 (33)	0.1 (-1.4, 1.7)	0.9 (-1.9, 3.8)	39
Low	190 (33)	0.3 (-1.3, 1.8)	0.1 (-2.8, 2.9)	34
Sodium Improvement				
High	190 (33)	-0.3 (-1.8, 1.2)	-0.6 (-3.4, 2.3)	40
Med	188 (33)	0.1 (-1.4, 1.7)	0.9 (-2.0, 3.8)	36
Low	193 (34)	-0.9 (-2.5, 0.6)	-1.2 (-4.1, 1.7)	40

Frequencies (%) of behavior change tertiles, estimate and 95%CI for the mean change in blood pressure over 12 months, and % of who improve SBP by at least 10mmHg or improve DBP by 5mmHg or more.