Original Report:
Cardiovascular Disease
and Risk Factors

Glucometabolic State Transitions: The Jackson Heart Study

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Background: Diabetes and prediabetes are common among African Americans (AA), but the frequency and predictors of transition between normal, impaired glucose metabolism, and diabetes are not well-described. The aim of this study was to examine glucometabolic transitions and their association with the development of type 2 diabetes (T2D).

Methods: AA participants of the Jackson Heart Study who attended baseline exam (2000-2004) and at least one of two subsequent exams (2005-2008 and 2009-2013, ~8 years) were classified according to glycemic status. Transitions were defined as progression (deterioration) or remission (improvement) of glycemic status. Multinomial logistic regression models with repeated measures were used to estimate the odds ratios (OR) for remission and progression with adjustment for demographic, anthropometric, behavioral, and biochemical factors.

Results: Among 3353 participants, (mean age 54.6±12.3 years), 43% were normoglycemic, 32% were prediabetes, and 25% had diabetes at baseline. For those with normal glucose at a visit, the probability at the next visit (~4years) of having prediabetes or diabetes was 38.5% and 1.8%, respectively. For those with prediabetes, the probability was 9.9% to improve to normal and 19.9% to progress to diabetes. Progression was associated with baseline BMI, diabetes status, triglycerides, family history of diabetes, and weight gain (OR 1.04 kg, 95% CI:1.03-1.06, P=<.0001). Remission was strongly associated with weight loss (OR .97 kg, 95%CI: .95-.98, P<.001).

Conclusions: In AAs, glucometabolic transitions were frequent and most involved deterioration. From a public health perspective additional emphasis should be placed on weight control to preserve glucometabolic status and prevent progression to T2D. *Ethn Dis*. 2022;32(3):203-212; doi:10.18865/ed.32.3.203

Keywords: African Americans; Glucometabolic States; Prediabetes; Diabetes Mellitus; Risk Factors; Weight Loss

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Introduction

African Americans (AAs) are disproportionately affected by type 2 diabetes (T2D) and chronic diseases.[1,2] Contributors to disparities in diabetes are higher rates of obesity, hypertension, lower rates of physical activity and access to health care.[2,3] These factors have been associated with higher glucometabolic progressions from normal glucose tolerance to prediabetes to T2D. However, there is little data on the progression rates. It is of utmost importance to have progression rates due to the implications for primary prevention. The Diabetes Prevention Program (DPP), a multiethnic population of individuals (45% ethnic minorities, including AAs), with impaired glucose tolerance (IGT) and impaired fasting glucose (IFG) demonstrated a 58% reduction in T2D incidence with an intensive lifestyle intervention.[3] Several clinical trials have examined the efficacy of lifestyle behavior change, medications, and/or bariatric surgery to prevent diabetes in people with prediabetes.[3-6] Together, these intervention studies have demonstrated 25%-67% reductions in T2D incidence over 2.5 to 6-year intervention periods, with most participants continuing their prediabetes state. Of interest,

but less frequently focused on, are the 20%–50% of participants who did not progress to T2D, but in fact, maintained their current glucometabolic state or returned to normal glucose regulation.[7-11] Conversely, a pooled analysis of three community-based cohort studies demonstrated that the duration and degree of weight gain,[12] as well as increase in modifiable lifestyle risk factors, were associated with incidence of diabetes.[13] However, little is known about which factors are associated with maintenance of normoglycemia among AAs who have higher rates of both prediabetes and T2D compared to White populations.[2,5,10]

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According to the Centers for Disease Control and Prevention, it is estimated that 88 million US adults have prediabetes, which includes both IFG and IGT.[1] In a meta-analysis of prospective cohort studies evaluating the risk of progression or remission of IFG and IGT, the relative risks for progression to T2D were 7.5, 5.5, and 12.1 for those with isolated IFG, isolated IGT and combined IFG/IGT, respectively, over 2-9 years.[14] Nonetheless, it is known that IFG may revert to normal; one review estimates that over 3-9 years, 25% develop T2D, 50% remain in IFG, and 25% revert to normal.[15] Most of these studies did not include AAs. Improvement in glucose tolerance from prediabetes to normal or from T2D to prediabetes or normal while off glucose-lowering medication, can occur, and has been reported with bariatric surgery[6] and lifestyle interventions.[7] Type 2 diabetes remission has been suggested to be a unique and distinguishing feature of T2D among some AAs and is a topic of continued debate.[8,16] However, no community-based longitudinal study has examined the transition between glucometabolic categories among AAs not enrolled in a formal lifestyle intervention. Understanding these transitions and the underlying factors associated with transitions between glucometabolic categories may be important in reducing the prevalence of prediabetes and T2D in AAs. We therefore examined longitudinal glucometabolic transitions in the Jackson Heart Study (JHS).

Methods

The JHS is a prospective cohort study of the development and progression of cardiovascular disease in AAs from the tri-county area (Hinds, Madison, and Rankin) of metropolitan Jackson, Mississippi. Details about the study design and recruitment process have been published.[17,18] Briefly, 5,306 participants aged 21-94 years were recruited between 2000 and 2004 to participate in a baseline examination; two subsequent in-person follow-up examinations occurred from 2005 – 2008 (Exam 2) and 2009-2013 (Exam 3) (average 8 years). We excluded 28 participants missing diabetes status at every visit, 21 with no diabetes status at exam, 990 with no follow-up glucose determination at exam 2 and 3, and 914 missing glucose information only at exam 2 (Figure 1). All procedures were in accordance with the ethical standards of the University of Mississippi Medical Center Institutional Review Board and the Helsinki Declaration of 1975, as revised in 2000. Written informed consent was obtained from all participants.

Data Assessment

Participants were interviewed during clinic visits or at home to obtain information on demographics, socioeconomic status, lifestyle data, and other sociocultural parameters. Certified technicians and nurses conducted clinic interviews and measurement of parameters including anthropometrics and vital signs. During visits, an inventory of currently prescribed drugs and over-the-counter medication was recorded. Resting blood pressure was measured twice at five-minute intervals and averaged. Hypertension was defined as blood pressure ≥140/90 mm Hg or use of blood pressure lowering medication. Height and weight were measured with participants wearing light clothing. BMI was determined as weight (kilograms) divided by height (meters) squared. Three BMI categories were defined: normal weight (BMI <25 kg/m^2), overweight (25≥ BMI ≤30, kg/m^2) and obesity (BMI ≥30 kg/m^2).

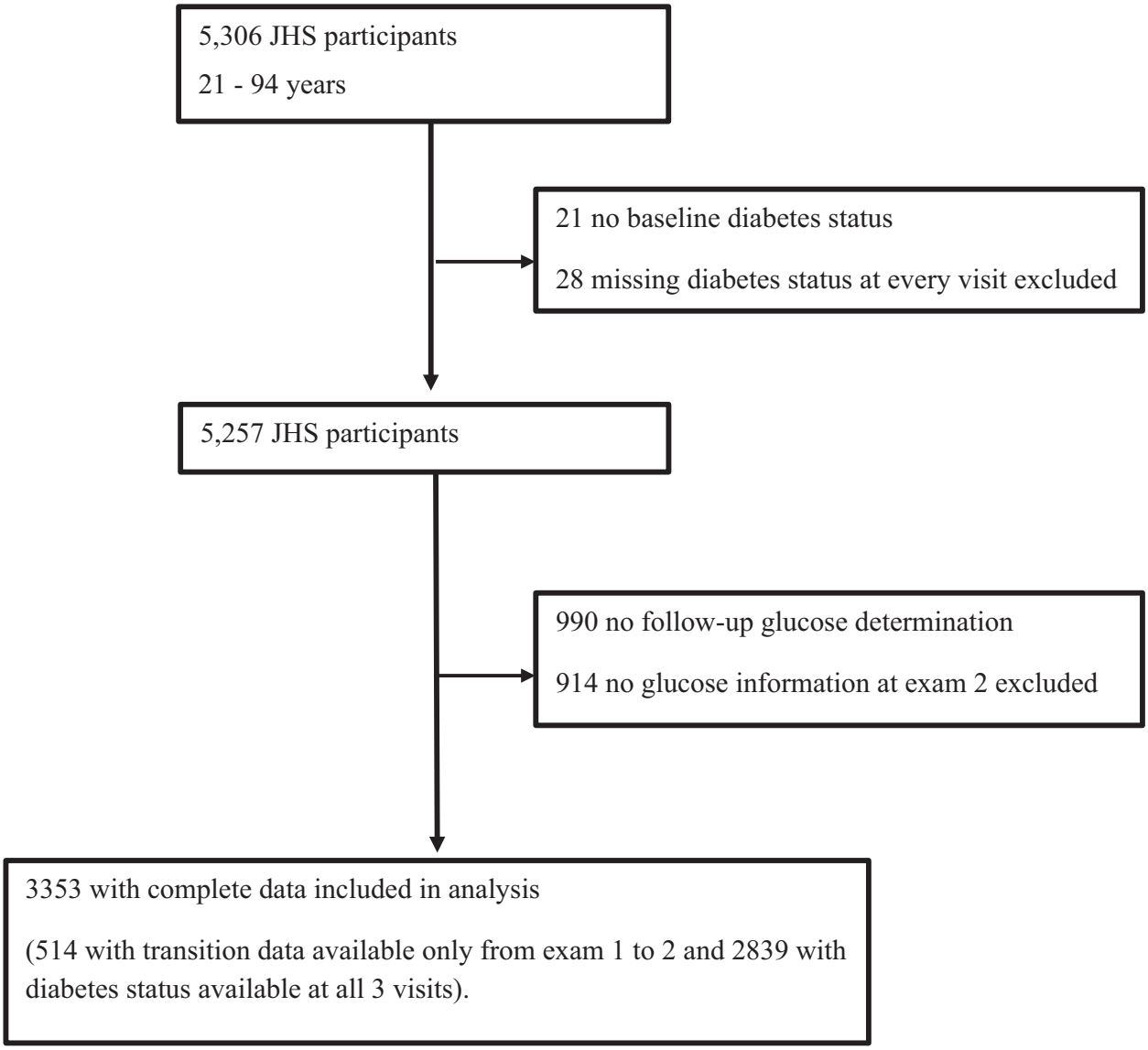

Figure 1. The participant flowchart shows that 3,353 participants were included in the final analytic cohort

Smoking was defined as self-reported cigarette smoking. Alcohol drinking was defined as alcohol drinking in the past 12 months. Physical activity was defined according to the American Heart Association categorization as: poor health (0 minutes of moderate and vigorous activity/week); intermediate health (>0 minutes but <150 minutes of moderate activity or >0 minutes but <75 minutes of vigorous activity or >0 minutes but <150 minutes of combined moderate and vigorous activity/week); and ideal health (≥150 minutes of moderate activity or ≥75 minutes of vigorous activity or ≥150 minutes of combined moderate and vigorous activity/week). Education level was characterized as less than high school vs high school graduate. Family history of diabetes was defined as history of a parent or sibling with diabetes. Income status was divided into four categories based on family size and income: poor; low income; middle income; and affluent groups.

Blood samples were collected according to standard procedures and metabolic variables were analyzed at a central laboratory (University of Min-

nesota).[17-19] Fasting glucose, lipids and insulin concentrations were measured on a Vitros 950 or 250, Ortho-Clinical Diagnostics analyzer (Raritan, New Jersey) using standard procedures that met the College of American Pathologists accreditation requirement.[19] A high-performance liquid chromatography system (Tosoh Corporation, Tokyo, Japan) was used to measure glycosylated hemoglobin A1c (A1c) concentrations.[19] Insulin resistance was measured in participants without diabetes using Homeostatic Model Assessment (HOMA) described by Matthews, ($HOMA_{IR}$) = (fasting plasma insulin [μU/ml]) X (fasting plasma glucose [mg/dl]) ÷ 22.5.[20]

High-sensitivity CRP (hsCRP) was measured by the immunoturbidimetric CRP-Latex assay (Kamiya Biomedical Company, Seattle, Washington) using a Hitachi 911 analyzer (Roche Diagnostics, Indianapolis, Indiana).[20] Measurement was done in duplicates, and any duplicates that were not within 3 assay SD from one another were rerun. The interassay coefficient of variation on control samples was 4.5% (hs-CRP level of .009 mg/l) and 4.4% (hs-CRP level of .033 mg/l).[19]

Diabetes mellitus was classified as normal, prediabetes, and diabetes based on glycemic status (fasting glucose, A1c, use of glucose-lowering medications). We used the American Diabetes Association criteria for normal glucose metabolism (fasting glucose <100 mg/dL and A1c <5.6%); Prediabetes was defined as fasting glucose between 100 mg/dL and 125 mg/dL or A1c 5.7-6.4% and not on glucose-lowering medications and diabetes was defined as fasting glucose ≥126 mg/dL or A1c ≥6.5 or being on diabetes medications.[21]

We calculated the probability of transitioning from one glucose status to another between one visit and the next, incorporating transitions between exam 1 & 2, and 2 & 3 (persons with 3 visits of data could transition twice). Progression was defined as worsening in glycemic status at a subsequent exam (normoglycemic to either prediabetes or diabetes; prediabetes to diabetes). Remission was defined as having an improvement in glucose status (ie, from diabetes to prediabetes or normal; prediabetes to normal).

Statistical Analysis

Descriptive statistics, means and standard deviations (SD) or frequencies and percentages, were used to describe the overall sample. We constructed a first-order Markov transition model to estimate the transition probabilities in and out of diabetes status (normal, prediabetes, and diabetes) averaged across two consecutive visits (visit 1 to 2 and visit 2 to 3). At each follow-up visit (visit 2 or 3), the transition status of a participant was classified as stable, remission, or progression based on the diabetes status of the current visit and the previous visit. Participants with glucose status at two or more continuous visits (ie, Exam 1 and 2, 2 and 3, or all three exams) and not missing data used to define diabetes were included in the analysis. We calculated weight change as differences in kg from visit 1 to visit 2; and from visit 2 to visit 3, adjusting for baseline demographic, anthropometric, behavioral, and biochemical factors.

Multinomial logistic regression models were fit to estimate the odds ratios (OR) for remission vs stable and progression vs stable, adjusting for baseline demographic, anthropometric, behavioral, and biochemical factors. Weight and (log) hsCRP change between two consecutive visits were included in the model as time-varying predictors. Taylor series method was used to estimate the variances of the parameter estimates to account for clustering of two transitions from the same individual across three visits. Statistical significance was defined as a two-sided P value <.05. All analyses were conducted using SAS 9.4 (Cary, NC).

Results

The final analytic cohort included 3,353 adults, which included 514 with transition data available only from exam 1 to 2 and 2,839 with diabetes status available at all three visits (Figure 1). Characteristics of this study group are presented in Table 1. Mean age was 54.6±12.3 years and 35% were males. The prevalence or risk factors associated with abnormal glucose metabolism was high, including obesity, hypertension, and physical inactivity. Fifty percent of participants had a family history of diabetes. The mean fasting plasma glucose was 100±33 mg/dL, A1c was 6±1.3 %, fasting plasma insulin 19±25 μU/l, and HOMA-IR was 3.5 ±2.3%. The fasting plasma total cholesterol was 199±39 mg/dL, the high-density lipoprotein cholesterol was 51.2±14.2 mg/dL, and the triglycerides were 104±70 mg/dL, and the hsCRP was .5±.8 mg/L. The mean systolic blood pressure and diastolic blood pressure were 127±16 and 76±9 mm Hg, respectively. At baseline, 43%, 32%, and 25% had normoglycemia, prediabetes and diabetes, respectively.

Transition Probabilities

The probabilities of transition are presented in Figure 2. Among those with normoglycemia at one time-point, the probability of progressing to prediabetes at the subsequent visit was 38.5% and of progressing to diabetes was 1.8%. If a JHS participant had prediabetes at a visit, the probability of remaining in the prediabetes state was 70.2%, progressing to diabetes was 19.9%, and of having remission to normal was 9.9%. Diabetes was the most permanent state (95% likelihood of remaining diabetic at the next visit), while remission occurred among 6% and .2% to the states of prediabetes and normoglycemia, respectively.

Correlates of Remission and Progression

Table 2 represents the correlates of transition states of participants. Remission was associated with baseline diabetes status, hsCRP change, and weight change. A 1-log unit increase in hsCRP change was associated with a 17% lower odds of diabetes remission (OR .83 (.71, .97), P=.0213). A 1-kg increase in weight change was associated with a 3% lower odds of diabetes remission (OR .97 (.95, .98), P<.0001). In addition, changes in baseline glucometabolic status from prediabetes vs normal (OR 1.44 (1.04, 1.99), P=.0296) and diabetes vs normal (OR .56 (.34, .93), P=.0249) were associated with remission. Weight increase of 1-kg was associated with a reduced likelihood of remission (OR .97 (.95, .98), P<.0001). Progression was associated with increase in baseline BMI, (log) triglycerides, (log) hsCRP, systolic blood pressure, and weight gain (OR 1.04 per kg, (1.03,1.06), P≤.0001). In addition, baseline diabetes status, use of blood pressure medication, triglycerides and family history of diabetes was associated with progression. Of note, the average weight change between exams was +1.4 kg for those experiencing only a progression and -4.5 kg for those with only a remission.

Table 1. Characteristics of the Jackson Heart Study sample at study baseline (2000-2004)

Clinical and Metabolic Characteristics	Overall Population, N=3,353
Age, years	54.6±12.3
Male,%	35
Baseline diabetes status	
Normal glycemia, %	43
Prediabetes, %	32
Diabetes, %	25
Family history of diabetes, %	50
Fasting plasma glucose, mg/dL	100.0±33.3
HbA1c (A1c) (%)	6.0±1.3
HOMA- IR (%) (N=2412)[a]	3.5±2.3
Fasting plasma insulin, μU/l	19±25
Education	
<High school, %	17
High school graduate, %	83
Income	
Poor, %	13
Lower middle, %	23
Upper middle, %	30
Affluent, %	34
Weight (kg)	91.2±21.1
Body mass index (BMI), kg/m^2	32 ± 7
BMI ≥ 30, %	55
25 ≤ BMI < 30, %	32
< 25, %	13
Hypertension, %	56
Systolic blood pressure, mm Hg	127±16
Diastolic blood pressure, mm Hg	76±9
Hypertensive medications, %	52
Former smoker, %	19
Current smoker, %	10
Alcohol use in last 12 months, %	46
Physical activity	
Poor physical activity, %	48
Intermediate physical activity	32
Ideal physical activity	20
Total cholesterol, mg/dL	199±39
High-density lipoprotein cholesterol, mg/dL	51.2±14.2
Triglycerides, mg/dL	104±70
Lipid-lowering medication, %	14
High sensitivity C-reactive protein (hsCRP) mg/L	.5±.8
High sensitivity C-reactive protein (hsCRP) mg/L (log)	-1.4 ±1.2

Means ± SD for continuous variables and (%) for categorical variable
a. Only in persons without diabetes

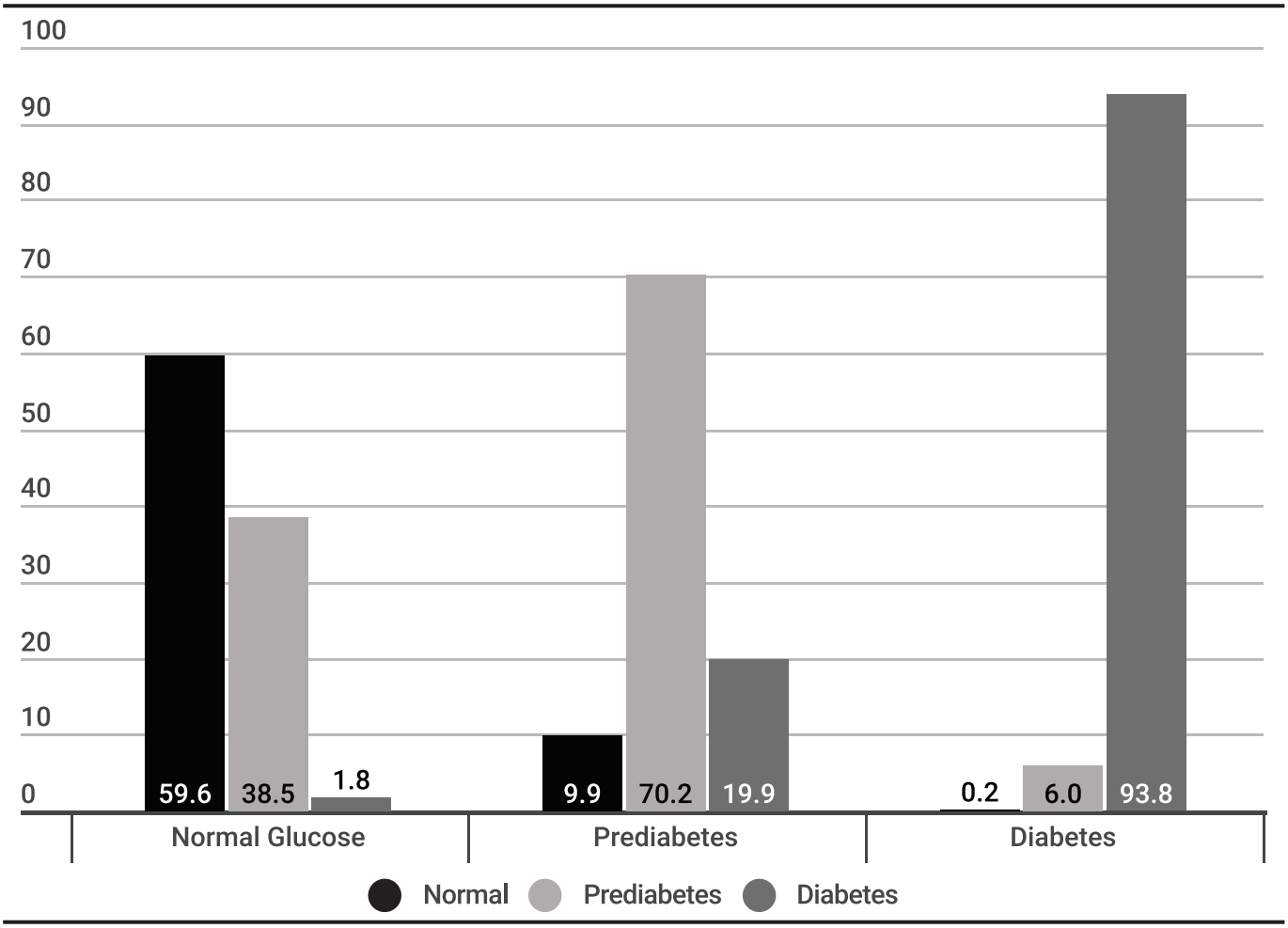

Figure 2. Probability of transition (%) during the JHS, Visit 1 (2000-2004), 2 (2005-2008) and 3 (2009-2013)

Discussion

In a contemporary adult AA population residing in a tri-county area of Jackson, Mississippi transitions between glucometabolic states were frequent and most involved deterioration. Improvement in glucometabolic status was rare, particularly among those with diabetes. It is particularly striking to see a substantial risk of transition from normal glucose status to IFG and prediabetes. We found that progression or deterioration of glycemia was associated with baseline BMI, diabetes status, weight gain, systolic blood pressure, use of antihypertensive medications, higher triglycerides and hsCRP, and family history of T2D. These results are consistent with prior literature including specifically prior reports of incident diabetes in JHS.[9,13,22] In contrast, the outcome of remission was rare, and the strongest association was with weight loss, normal glycemia and lower hsCRP. Not surprisingly, diabetes was associated with little change, with most participants remaining with diabetes at follow-up visits. These data are consistent with the epidemiology of diabetes in the United States, particularly in Mississippi.[1, 23-25]

Glucometabolic Remission

Modest weight loss has been associated with reduction in cardiovascular risk factors in recent intervention studies.[3-9,26,27] The Diabetes Prevention Program (DPP) demonstrated that a 7%–10% reduction in body weight can reduce the risk of developing T2D by 58% in persons with impaired glucose tolerance.[3] Every 1-kg weight loss was associated with a 16% reduction in diabetes incidence.[9] In the SHAPE program, a modest lifestyle intervention for AA women delivered in a primary care setting by advance practice nurses utilizing eHealth technology

Table 2. Correlates associated with glucometabolic remission and progression among participants in the Jackson Heart Study

	Glucometabolic Transition States	
	Remission vs Stable	**Progression vs Stable**
Predictor	**Odds Ratio (95%CI), P**	**Odds Ratio (95% CI), P**
Sociodemographic measures		
Age, years	1.00 (.99, 1.02) P=.5509	1.01 (1.00, 1.01) P=.1350
Male vs female	1.02 (.76, 1.37) P=.8781	1.06 (.93, 1.22) P=.3894
<High school graduate vs high school graduate	.73 (.50, 1.07) P=.1053	1.01 (.82, 1.25) P=.8927
Behavioral measures		
Alcohol	1.18 (.89, 1.58) P=.2575	.97 (.85, 1.11) P=.6788
Former vs never moking	1.07 (.76, 1.51) P=.6825	1.03 (.86, 1.22) P=.7607
Current vs never smoking	.86 (.52, 1.41) P=.5443	1.04 (.85, 1.28) P=.6938
Biological Measures		
Systolic blood pressure, mm Hg	1.04 (.94, 1.15) P=.4108	1.06 (1.01, 1.11) P=.0115[a]
Blood pressure medications	1.01 (.75, 1.36) P=.9512	1.15 (1.00, 1.33) P=.0467[a]
Body mass index, kg/m2	1.02 (1.00, 1.04) P=.0991	1.04 (1.03, 1.05) P<.0001[a]
Weight change, kg	.97 (.95, .98) P<.0001[a]	1.04 (1.03, 1.06) P<.0001[a]
hsCRP change, mg/L, log-transformed	.83 (.71, .97) P=.0213[a]	1.16 (1.05, 1.27) P=.0026[a]
Triglycerides, mg/dlL, log-transformed	1.00 (.74, 1.34) P=.9807	1.29 (1.14, 1.47) P<.0001
Baseline glucometabolic status		
Prediabetes vs normal	1.44 (1.04, 1.99) P=.0296[a]	.44 (.38, .51) P<.0001[a]
Diabetes vs normal	.56 (.34, .93) P=.0249[a]	.02 (.01, .03) P<.0001[a]
Family history of diabetes	.80 (.61, 1.06) P=.1164	1.30 (1.15, 1.47) P<.0001[a]

hsCRP, high-sensitivity C-reactive protein
a. P<.05

with an average weight loss of 1.7 kg compared to controls demonstrated no development of diabetes among participants with weight loss.[26] These findings indicate that even modest weight loss may have important effects on the incidence and course of obesity-related chronic disease, such as T2D. This finding has clinical and public health implications considering the higher rates of obesity and T2D among AA women. In the JHS, an observational study, average weight loss of -4.5 kg for those with only a remission was associated with a return to normoglycemia. This occurred in the absence of standardized weight loss or behavioral counseling intervention, to the best of our knowledge. In another examination of the JHS,[13] a combination of modifiable lifestyle risk factors including physical activity, television watching time, healthy diet, smoking and sleep disordered breathing were associated with lower risk of developing diabetes independent of adiposity, with a greater magnitude among participants with BMI <30 kg/m^2. This is an important finding, since weight change was not analyzed over time just the effects of modification by baseline weight status, thus, indicating additional factors related to adiposity may also be important in understanding glucometabolic progressions.[13]

The role of inflammation in the development of prediabetes and diabetes has been well-documented. In our study we found that remission was associated with lower hsCRP levels when compared to progression. Similarly in the Pathobiology of Prediabetes in A Biracial Cohort (POP-ABC) study, lower hsCRP was observed in those individuals who did not progress to diabetes but maintained normal glucose status.[28]

Glucometabolic Progression

Weight gain and its associated comorbidities is also associated with future development of T2D. In the current study, weight transitions were common between visits, with weight gain associated with progression to prediabetes and T2D. Other factors associated with progression or deterioration of glycemia were baseline BMI, diabetes status, higher triglycerides and log-hsCRP, systolic blood pressure, usages of antihypertensive medications, and family history of T2D. The average weight change between exams was +1.4 kg for those experiencing progression only. In

another study in high-risk AAs with family history of T2D, the predictors of progression to T2D over 6-year follow-up were weight gain (average 2.3 kg) and higher rates of obesity (measured by BMI).[5] The POP-ABC study of offspring of AAs and Whites with family history of T2D, found no racial differences in those who progressed from normoglycemia to prediabetes.[28] The predictors of progression in the POP-ABC study were age, male sex, higher BMI, weight gain, fasting plasma glucose, A1c and HOMA-IR. In the JHS, we did not find any sex difference related to progression. One possible explanation for the lack of sex difference may be related to the difference in ages, the participants in the POP-ABC study were younger (mean age 44 years) compared to the JHS (mean age 55 years).

These findings indicate that even modest weight loss may have important effects on the incidence and course of obesity-related chronic disease, such as T2D.

There are metabolic characteristics that are often associated with progression from normoglycemia to IFG and IGT and prediabetes. These include high fasting and 2-hour glucose and insulin levels as measured by oral glucose tolerance test as well as higher A1c and greater insulin resistance. In the JHS, participants who progressed to T2D, in addition to having weight fluctuations, had higher rates of baseline prediabetes and thus we can assume IFG and IGT as well as more modifiable risk factors.[13] Osei et al demonstrated that AAs with family histories of T2D, who progressed to T2D, had higher A1c, fasting and 2-hour glucose and insulin levels, as well as HOMA-IR when compared to non-progressors.[5] In the POP-ABC study, fasting and 2-hour plasma glucose, A1c, HOMA-IR and hsCRP were greater in the progressors when compared to those who maintained normoglycemia.[28] In the JHS, we found that those who progressed to T2D had differences in baseline diabetes status, but no difference in fasting glucose or insulin levels nor HOMA-IR. A meta-analysis examining disparities in A1c among ethnic groups of persons with T2D found higher A1c values among AAs when compared to other racial groups.[29] Similar findings were demonstrated in the National Health and Nutrition Examination Survey (NHANES) and the DPP.[30, 31] In the JHS, oral glucose tolerance test was not performed, thus we cannot ascertain the impact of post-prandial glucose in our study.

Baseline Glucometabolic Status

In the current study of middle-aged AAs of the JHS, we found several correlates associated with glucometabolic transitions. For example, remission was associated with weight change and lower hsCRP (log). There were also several biological factors associated with progression to T2D. Note that more than 50% of our study population had a family history of diabetes, were hypertensive and were on antihypertensive medications. Furthermore, systolic blood pressure, higher hsCRP (log) and triglycerides, weight change and increase adiposity (55%-BMI ≥30 kg/m^2) were associated with progression to T2D. These finding were similar to other populations followed longitudinally over 8.9[12] and 21 years.[32] These studies demonstrate the need to aggressively monitor and manage these traditional risk factors in AAs because of the greater risks of developing diabetes than Whites.

Limitations and Strengths

In the current study of high-risk AAs in the JHS, we report several limitations. First, the JHS is an observational study that sought to examine transitional states of glycemia (progression and/or remission) during follow-up visits. Thus, our findings may not be directly comparable to other published interventional and or follow-up studies, such as the DPP[3] and the DPPOS (outcome study).[9] Second, the JHS did not measure glucose tolerance (oral glucose tolerance test), as was performed in the DPP[3] and DPPOS,[9] study by Osei[5] and POP-ABC studies.[28] The lack of an oral glucose tolerance test may underestimate the progression from normoglycemia to prediabetes and prediabetes to diabetes. Third, the JHS occurred in Mississippi, with higher rates of T2D, and obesity, limiting its generalizability to other populations of AAs residing in diverse geographical locations.[25,33] In spite of these limitations, our study has several strengths. The JHS is a well-characterized population of AAs with more than 10 years of longitudinal data regarding glucose status (fasting glucose, A1c, HOMA-

IR, diabetes medications) and other metabolic characteristics (BMI, weight, blood pressure and lipids, smoking and physical activity). Second, we modeled transitions as they occur in a population, rather than assume that once a participant has developed an abnormal glucose state that they remain in that state at subsequent examinations.

Conclusion

In the JHS, glucometabolic transitions, including remission or progression of glycemia, were common. Remission was influence by decreases in weight and lower baseline hsCRP, while progression was influenced by a number of factors including baseline BMI, systolic blood pressure, blood pressure medications, hsCRP, triglycerides, family history of diabetes, glucometabolic status and weight change (gain). Remission was infrequent, as was found in other studies.[8,9,11]

It is well-established that being overweight or obese increases the likelihood of developing prediabetes or diabetes. With its longitudinal design, the current study adds to the public health importance of prevention of weight gain and adiposity associated risk factors (eg, elevated blood pressure, triglycerides, and inflammation [hsCRP]), which are associated with adverse glucometabolic transitions. Strategies that incorporate the importance of weight loss have been emphasized and encouraged as part of clinical and public health strategies aimed at prevention of diabetes. We believe these results suggest that incorporation of "maintain don't gain" concepts may also potentially reduce adverse glucometabolic transitions.[26,27] Most importantly, primary care providers should discuss the importance of weight maintenance and/or loss in younger adults, considering the duration of weight gain has also been associated with incidence of diabetes.[12] Additionally, the frequency of developing either prediabetes or diabetes in this cohort highlights the importance of expanding diabetes prevention programs, as well as referring persons to such programs. Unfortunately, there is evidence that only 4% of National Health Interview Survey participants potentially eligible for a lifestyle intervention were ever offered a referral, and only 2% had ever participated in such a program.[34] Thus additional, efforts are warranted to educate primary care providers on the availability of the lifestyle intervention programs in the community so that they can be further utilized. Furthermore, these programs should be easily accessible, equitable and tailored to meet the needs of the target population.

Acknowledgments

The Jackson Heart Study (JHS) is supported and conducted in collaboration with Jackson State University (HHSN268201800013I), Tougaloo College (HHSN268201800014I), the Mississippi State Department of Health (HHSN268201800015I) and the University of Mississippi Medical Center (HHSN268201800010I, HHSN268201800011I and HHSN268201800012I) contracts from the National Heart, Lung, and Blood Institute (NHLBI) and the National Institute on Minority Health and Health Disparities (NIMHD).

The authors also wish to thank the staffs and participants of the JHS. Joshua J. Joseph was supported by The Robert Wood Johnson Foundation (Harold Amos Medical Faculty Development Program ID# 76236) and the National Institute of Diabetes and Digestive and Kidney Diseases (K23DK117041, JJJ) of the National Institutes of Health.

Disclaimer: The views expressed in this manuscript are those of the authors and do not necessarily represent the views of the National Heart, Lung, and Blood Institute; the National Institutes of Health; or the U.S. Department of Health and Human Services.

Conflict of Interest

No conflicts of interest to report.

Author Contributions

Research concept and design: Effoe, Correa, Kalyani, Joseph, Bertoni; Acquisition of data: Correa; Data analysis and interpretation: Gaillard, Chen, Effoe, Correa, Carnethon, Echouffo-Tcheugui, Joseph, Bertoni; Manuscript draft: Gaillard, Effoe, Kalyani, Echouffo-Tcheugui, Joseph, Bertoni; Statistical expertise: Chen, Effoe, Carnethon, Echouffo-Tcheugui, Joseph; Acquisition of funding: Correa, Bertoni; Administrative: Gaillard, Correa, Kalyani, Echouffo-Tcheugui, Joseph; Supervision: Bertoni

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