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FASTING PLASMA GLUCOSE AND HEMOGLOBIN A1C DIFFER BY GENDER AND RACE AMONG EMERGING ADULTS

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Healy et. al. Objective: To examine the relationship between, and disparities in, glycemic markers among emerging adults. **Methods**: A diverse group of emerging adults affiliated with a large university located in the Northeast of the US were recruited. Participants self-reported demographic information, and lipids and glycemic markers were assessed using a finger-stick screening with participants fasted for a minimum of 9-12 hours before blood sampling. **Results**: Data were collected from 217 participants (21±2 years). Regardless of gender or race, no statistically significant relationship was found between FPG and either HbA_{1C}. However, those of 'other' races were found to have significantly higher FPG and HbA_{1C} compared to non-Hispanic white participants, and gender differences in glycemic markers were only observed among non-Hispanic white participants. **Conclusions**: While limited by a relatively small sample size, findings reinforce the importance of recognizing racial differences in glycemic markers when diagnosing and treating diabetes given racial disparities were observed in otherwise healthy emerging adults.

Key Words: young adults; college students; diabetes; metabolic syndrome

INTRODUCTION

Diabetes is the seventh leading cause of death in the United States (U.S.) (Centers for Disease Control and Prevention [CDC], 2017a), and imposes a considerable financial burden on individuals and the healthcare system (American Diabetes Association [ADA], 2013). Nearly one in ten of adults in the U.S. have diabetes, a further third are considered pre-diabetic, and many more are undiagnosed (CDC, 2017b) demonstrating the importance of accurate and reliable testing.

Diabetes is most commonly diagnosed through blood glucose analyses. The two methods to test blood glucose are fasting plasma glucose (FPG) and glycated hemoglobin A1C (HbA_{1C}). FPG is the most common method and assesses short-term blood glucose levels (ADA, 2014a), whereas HbA_{1C} test is the preferred method of assessing long-term blood sugar levels. While both tests can provide an indication of whether individuals are characteristic of pre-diabetes, the nature of the relationship between HbA_{1C} and FPG remains unclear among otherwise healthy emerging adults.

Previous findings indicate that there is a linear or curvilinear relationship between FPG and HbA_{1C} among adults irrespective of race and diabetic status (Ramachandran et al., 2012; van 't Riet et al., 2010). However, it is well established that glycemic markers vary based on race (Bergenstal et al., 2017; Cavagnolli et al., 2017; Guo et al., 2014; Herman & Cohen, 2012) even among youth (Kahkoska et al., 2018; Willi et al., 2015). Such variations risk misdiagnoses of whether or not individuals have diabetes (Guo et al., 2014). Moreover, there is disagreement concerning the diagnostic criteria for FPG and HbA_{1C}. For example, HbA_{1C} diagnostic criteria, with ≥ 6.5% the most stringent criteria (ADA, 2014b), though evidence suggests that the optimal cut-off is closer to <6% (Kaur et al., 2020). At present, recommendations

suggest accounting for medical history and existing medical conditions when considering glycemic goals, but race is not mentioned as a factor to consider when making decisions (ADA, 2014b).

Thus, when screening patients to diagnose diabetes, appreciation of glycemic marker variation is important for both accurate diagnoses and prescription of appropriate treatment (Sacks, 2011). Failure to acknowledge racial differences has potential to do harm (Herman, 2016; Selvin, 2016). As previous studies have mainly involved youth or older adults, it is important to examine the relationship between FPG and HbA_{1C} among otherwise healthy emerging adults. Thus, the purpose of this study was to examine the relationship between FPG and HbA_{1C} among emerging adults, and differences based on gender and race.

METHODS

Participants

Data were collected from individuals affiliated with a large university located in the Northeast of the US between September 2018 and March 2019. Students were recruited from general education health and wellness courses, with other students recruited via word of mouth (N=207). A variety of recruitment methods were required to achieve the necessary level of diversity to allow for investigation of differences based on race in a predominantly non-Hispanic white community. The remaining 10 participants were high school students, at least 18 years of age with a dual-enrollment affiliation to Pennsylvania State University, that were recruited from community outreach events. All participants provided informed written consent, and trained technicians administered tests. The Pennsylvania State University Institutional Review Board approved this study.

Protocol

Upon consenting to participate, participants completed a questionnaire that encompassed demographics and past medical history. The questionnaire served as a screening tool, before participants proceeded to the phlebotomy area where finger prick tests were administered. Participants were instructed to abstain from food and caffeine for eight hours, alcohol for 24 hours, and smoking and exercise for at least two hours prior to testing. Participants reporting one or more adverse condition that could influence red blood cell count were excluded from analyses.

Measures

Demographics. Participants self-reported their demographics, including age, gender, and race.

Medical/health history. Participants responded (yes/no) to 10 items regarding past medical/health history that may influence primary variables within the study (glucose, HbA1c). Six items pertained to whether participants had ever been told they had the following conditions that could affect red blood cell lifespan and therefore HbA1C: anemia, sickle cell anemia, iron deficiency, or hemolytic anemia, diabetes mellitus (type 1 or 2), abnormally functioning spleen (World Health Organization [WHO], 2011). Another item asked whether participants were currently receiving iron replacement therapy. Two further items asked whether they had had a recent (3 months) blood transfusion or their spleen removed. The final item asked whether they had a family history of diabetes.

Lipids and glycemic markers. Participants underwent a lipid-glucose test and HbA_{1C} test administered via finger prick. Blood was collected via fingerstick. The finger was cleaned with alcohol and allowed to air dry. Using a single use lancet, the finger was pricked and a drop of blood was allowed to form on the finger. This initial drop of blood was wiped away and 40 microliters of blood was collected into a capillary tube for lipid and fasting plasma glucose measurement with the Cholestech LDX. An additional 5 microliters of blood were collected into the A1cNow+ collection device for determination of HbA1c using this device. In participants undergoing a second HbA1c measure, an additional 1 microliter of whole blood was collected into the Seimens DCA Vantage collection device.

An Alere Cholestech LDX System analyzer (Abbot Labs, Chicago, IL) was used to perform a lipid profile, cholesterol, and glucose assessment of the bloodstream. The Cholestech machine was calibrated prior to each testing session. Additionally, a commercially available A1cNow+ System (Polymer Technology Systems [PTS] Diagnostics, Indianapolis,

IN) was used to provide HbA_{1C} readings. Five months into the study, a second HbA_{1C} instrument, the DCA Vantage Analyzer (Seimens Medical Solutions USA, Inc.), was purchased with a university approved grant and incorporated as a second HbA1c measurement into the study. This DCA was included given its well-established clinical accuracy (Lenters-Westra & Slingerland, 2010). About a third of participants received all three tests (one lipid-glucose profile, and both HbA_{1C} tests), while the remainder received the initial standard protocol of one lipid-glucose and one HbA_{1C} test. Both the DCA Vantage Analyzer and PTS Diagnostics A1cNow+ instruments calculate glycosylated hemoglobin scores according to the following equation: % HbA_{1C} = (HbA_{1C} /Total Hemoglobin) x 100 (Seimens Medical Solutions USA, Inc.). Neither require calibration. A retest was conducted in instances when a value was outside of the detectable range.

Statistical Analyses

Descriptive statistics were computed to characterize the sample. Pearson correlation coefficients were computed to examine the relationship between blood glucose measures. Independent sample t-tests were used to examine differences in fasting plasma glucose, HbA_{1C} (from PTS and DCA machines), total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglycerides based on gender and race separately. For race, participants were grouped into those identifying as either non-Hispanic white or 'other races' due to the small sample size. All analyses were run using SPSS 26.0 (IBM, Armonk, NY), with significance levels set at $p < .05$.

RESULTS

Participant Characteristics

The mean age of the two hundred and seventeen emerging adults participated in the study was 21±2 years. The majority identified as men (N=114, 52.5%), with the remainder identifying as women (N=103, 47.5%). The largest racial group was non-Hispanic white (N=117, 54%), followed by non-Hispanic Asian (N=44, 20%), Hispanic/Latinx (N=27, 12%), non-Hispanic African American (N=12, 6%), non-Hispanic Middle Eastern (N=11, 5%), and non-Hispanic mixed (N=6, 3%).

Relationships between glycemic markers

Among all participants, very weak non-statistically significant relations between FPG and both HbA_{1C} PTS and DC, and a moderate statistically significant relation between HbA_{1C} measures were revealed. Similar results were observed with respect to the relation between FPG and HbA_{1C} measures among those identifying as non-Hispanic white, but the relation between HbA_{1C} measures was very weak and not statistically significant. Similar results were observed pertaining to the relation between FPG and HbA_{1C} measures among those identifying as other races, but the relation between HbA_{1C} measures was strong and statistically significant (Table 1).

Table 1.

Relationships (correlation coefficients) between glycemic markers separated by race

	PTS	DC
All		
FPG	0.083	0.007
PTS		.479*
Non-Hispanic White		
FPG	0.151	-0.095
PTS		0.069
Other Races		
FPG	-0.053	0.033
PTS		.749*

Note. * < 0.05

Differences based on gender and race

Compared to women, men reported significantly lower HDL (moderate to large difference), higher LDL (small to moderate difference), lower triglycerides (moderate difference), higher glucose (moderate difference), and lower HbA1C DCA (moderate difference). Similar results were observed when examining differences between men and women identifying a non-Hispanic white. By contrast, when examining gender differences among those identifying as other races, similar findings to the overall sample were observed with the exception of triglycerides, fasting plasma glucose, and HbA1C PTS for which there were no statistically significant

differences between genders. The only statistically significant differences between racial groups found was that participants of other races had moderately higher HbA1C PTS and HbA1C DCA compared to non-Hispanic white participants (Table 2).

Table 2.

Differences in lipids and glycemic markers based on gender and race

	Gender						Race					
	Men (n=114)		Women (n=103)		*p*	η^2	Non-Hispanic white (n=117)		Other races (n=100)		*p*	η^2
	M	SD	M	SD			M	SD	M	SD		
HDL (mg/dL)	52.3	13.7	65.1	19.9	< .001	0.12	57.9	18.2	58.9	18	.660	.00
LDL (mg/dL)	99.4	42.1	86.7	29.8	.020	0.03	91.8	36.9	95.4	37.9	.510	.00
Total cholesterol (mg/dL)	166.3	39.2	172.0	31.6	.230	0.01	165	36.4	173.6	34.9	.080	.01
Triglycerides (mg/dL)	88.3	41.9	115.8	64.4	< .001	0.06	95.5	48.5	108	61.9	.100	.01
FPG (mg/dL)	92.6	8.7	88.5	8.9	.001	0.05	89.6	9.4	91.8	8.4	.070	.01
HbA_{1C} PTS (%)	5.0	0.5	5.0	0.4	.770	0.00	4.9	0.4	5.2	0.5	< .001	.08
HbA_{1C} DCA (%)	5.3	0.2	5.4	0.2	.040	0.06	5.3	0.2	5.5	0.27	.020	.08

Notes. HDL = High Density Lipoprotein; LDL = Low Density Lipoprotein; TC = Total Cholesterol; FPG = Fasting Plasma Glucose; Hemoglobin A1C = HbA_{1C}

DISCUSSION

The purpose of this study was to examine the relationship between FPG and HbA_{1C} among emerging adults, as well as differences based on gender or race. In contrast to previous studies involving older adults (Ramachandran et al., 2012; van 't Riet et al., 2010), no relationship was found between FPG and either HbA_{1C} measure. This may be attributable to the age of the participants and/or the small sample size in the current study.

Consistent with previous research involving young adults, men had greater LDL and glucose, whereas women had greater HDL and triglycerides (Wilson et al., 2020). Men were also found to have higher levels of HbA_{1C} based on the DCA, but not the PTS, measure. However, gender differences in glycemic markers were only observed among non-Hispanic white participants, and not those identifying as other races. This may be attributable to non-Hispanic white individuals having lower HbA_{1C} levels compared to those of other races. In addition, findings indicate that disparities exist among otherwise healthy emerging adults, whereas previous research involved diabetic youth (Kahkoska et al., 2018; Willi et al., 2015).

This study is limited by a relatively small sample size and the inability to examine differences between specific racial groups, let alone disparities based on the intersection of gender and racial groups. However, given the otherwise healthy status participants in this study, findings further reinforce the importance of recognizing racial differences in glycemic markers when diagnosing and treating diabetes. Moreover, findings highlight the importance of adopting an individualized approach for diabetes diagnoses and treatment in an clinical setting (Selvin, 2016). Further research is required to further investigate the relationship between glycemic markers among young and/or healthy populations, as well as the influence that the intersection of gender and race have on glycemic markers and their relationship with one another.

CONCLUSION

While limited by a relatively small sample size, findings reinforce the importance of clinicians adopting an individualized approach to diagnoses and treatment of diabetes that facilitates recognition of racial differences in glycemic markers among emerging adults.

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