Serum 25-Hydroxy Vitamin D and Insulin Resistance, Metabolic Syndrome, and Glucose Intolerance Among Arab Americans

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OBJECTIVE — To describe 25-hydroxy vitamin D (25-OH-D) levels and examine associations between 25-OH-D levels and insulin resistance (IR), metabolic syndrome (MS), and glucose intolerance in Arab Americans.

RESEARCH DESIGN AND METHODS — Serum 25-OH-D levels were measured in a representative, cross-sectional sample of 542 Arab Americans with IR (46%), MS (33%), and glucose intolerance (42%).

RESULTS — Vitamin D insufficiency (5 to <20 ng/ml) was present in 75% and hypovitaminosis D (20 to <40 ng/ml) in 24% of participants. In men, 25-OH-D levels were lower in those with glucose intolerance than normoglycemia ($P = 0.01$). No such difference was found in women. In men, 25-OH-D was negatively correlated with homeostasis model assessment of insulin resistance ($r = -0.19$; $P = 0.0043$), triglycerides ($r = -0.18$; $P = 0.0069$), fasting plasma glucose ($r = -0.15$; $P = 0.027$), and A1C ($r = -0.14$; $P = 0.038$). In women, 25-OH-D was positively correlated with HDL ($r = 0.19$; $P = 0.0008$).

CONCLUSIONS — Vitamin D insufficiency and hypovitaminosis D are extremely common among Arab Americans, and they are associated with IR, components of the MS, and glucose intolerance in men.

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Altered calcium and vitamin D homeostasis are associated with insulin resistance (IR), reduced β-cell function, metabolic syndrome (MS), glucose intolerance, and diabetes (1–4). We have previously shown that the age- and sex-standardized prevalence of diabetes is 18% among Arab Americans (5–6). Although previous studies have documented an association between 25-hydroxy vitamin D (25-OH-D) levels and glucose intolerance, few have focused on the Arab American community, a culturally unique, under-studied, and medically underserved community in which traditional dress may limit sun exposure and dietary preferences may further contribute to 25-OH-D deficiency. The purpose of this study was to describe levels of 25-OH-D and examine associations between 25-OH-D levels and IR, MS, and glucose intolerance among Arab American adults.

RESEARCH DESIGN AND METHODS

— The methods have been described in detail elsewhere (5–7). Briefly, we studied 542 randomly selected Arab Americans 20–75 years of age. Demographic, anthropometric, and behavioral characteristics were measured. To examine food preferences, we calculated the ratio of Arab meals to total meals consumed in 1 week; a higher ratio indicates consumption of more Middle Eastern foods (diet rich in meat, yogurt, grains, and vegetables, and low in food fortified with vitamin D such as milk and breakfast cereals). Subjects performed strenuous physical activity if they engaged in exercise for ≥20 min that made them breathe hard and sweat ≥3 times per week. Those engaging in strenuous activity <3 times weekly performed moderate physical activity and all others were considered inactive. Smoking status was self-reported and verified by serum cotinine (Siemens Healthcare Diagnostics, Deerfield, IL). Acculturation was assessed with a validated four-item survey.

Fasting glucose, insulin, lipids, and A1C were measured and glucose tolerance assessed with 75-g oral glucose tolerance tests. IR was defined as homeostasis model assessment of insulin resistance ≥3.8 (8). Subjects meeting the revised National Cholesterol Education Program Adult Treatment Panel III criteria were defined as having MS (9). Glucose intolerance was defined as impaired fasting glucose, impaired glucose tolerance, or diabetes (10).

Serum 25-OH-D samples were coded, centrifuged, and stored at −70°C. In 2009, serum 25-OH-D was measured using the ^{125}I Radioimmunoassay kit (DiaSorin, Stillwater, MN) and quality control materials provided by the manufacturer. The inter-assay coefficients of variation are 7.3% at 13.7 ng/ml and 9.6% at 53.4 ng/ml. 25-OH-D status was classified as: deficiency, <5 ng/ml; insufficiency, 5 to <20 ng/ml; hypovitaminosis D, 20 to <40 ng/ml; sufficiency, 40 to <100 ng/ml; and toxicity, ≥100 ng/ml (11).

All analyses were performed separately by sex. Data are expressed as means ± SD or percentage. Continuous or categorical data were analyzed utilizing ANOVA or χ^2 tests. 25-OH-D levels were described by demographic, anthropometric, behavioral characteristics and by measures of disease status. Spearman correlation coefficients were calculated to examine the association between 25-

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Table 1—*Vitamin D levels as a function of glucose tolerance status and other factors*

	Men				Women			
	Normoglycemia	Glucose intolerance	*P**	Total (men)	Normoglycemia	Glucose intolerance	*P**	Total (women)
Sample size	103	111		214	204	113		317
All	19.4 ± 7.0	16.9 ± 5.5	0.005	18.1 ± 6.4	14.1 ± 7.6	14.0 ± 6.2	0.95	14.1 ± 7.1
Age (years)*			0.94				0.92	
20–29	20.1 ± 6.2	16.1 ± 4.5		18.6 ± 5.9	13.8 ± 6.8	15.7 ± 9.5		14.0 ± 7.1
30–39	19.3 ± 8	16.8 ± 7		18.3 ± 7.7	15 ± 9.3	13.2 ± 5.9		14.8 ± 8.9
40–49	20.6 ± 7.2	16.8 ± 5.2		18.2 ± 6.2	13.8 ± 7.3	11.9 ± 3.5		13.1 ± 6.2
50–59	17.5 ± 5.7	17.4 ± 5.9		17.4 ± 5.7	12.5 ± 4.3	15.2 ± 7		14.3 ± 6.3
≥60	17.6 ± 5.1	17.4 ± 4.7		17.5 ± 4.7	13.2 ± 4.3	14.4 ± 6.1		14.1 ± 5.7
BMI (kg/m^2)*			0.31				0.16	
<30	19.1 ± 7.2	17.6 ± 5.9		18.4 ± 6.6	14.3 ± 8.5	16.3 ± 6.8		14.8 ± 8.1
30 to <35	20.8 ± 6.3	15.9 ± 4.5		18 ± 5.8	12.8 ± 5	12.7 ± 5.5		12.8 ± 5.2
≥35	18.8 ± 8.2	13.3 ± 4.1		15.8 ± 6.7	14.2 ± 5.2	12.9 ± 5.7		13.4 ± 5.5
Food preference†*			0.15				0.50	
<0.5	20.7 ± 6.1	§		21.6 ± 6.3	18.6 ± 7.6	§		18 ± 7.4
0.5 to <0.8	18.7 ± 6.5	16.5 ± 6		17.9 ± 6.4	15.1 ± 7.3	13.7 ± 5.2		14.6 ± 6.7
0.8†	18.1 ± 6.2	16.7 ± 5.5		17.2 ± 5.8	12.8 ± 5.9	13.9 ± 5.9		13.2 ± 5.9
Physical activity*			0.22				0.98	
Strenuous/moderate	19.7 ± 7.6	17.5 ± 5.3		18.6 ± 6.6	14.6 ± 9.2	14.1 ± 7.2		14.4 ± 8.6
Light/inactive	19 ± 6.2	16.1 ± 5.8		17.4 ± 6.1	13.7 ± 6	14.2 ± 5.6		13.8 ± 5.8
Smoking status*			0.44				0.27	
Current smoker	18.6 ± 6.3	16.6 ± 5.6		17.7 ± 6.1	14.5 ± 7.5	12.9 ± 4.8		14 ± 6.9
Former smoker	19.9 ± 6.4	17.9 ± 3.3		18.7 ± 4.7	17.5 ± 7.5	15.3 ± 5.3		16.5 ± 6.5
Never smoker	20.4 ± 7.9	16.9 ± 6		18.4 ± 7	13.7 ± 7.6	14.3 ± 6.7		13.9 ± 7.2
Cotinine Status‡*			0.04				0.78	
<10	20.2 ± 7.5	16.8 ± 5.6		18.2 ± 6.7	14.2 ± 7.7	14 ± 5.9		14.1 ± 7.1
10–99	21.3 ± 6.2	19.6 ± 4.9		20.5 ± 5.6	12.7 ± 3.8	12.2 ± 3		12.6 ± 3.6
100–199	17.3 ± 6.5	16.9 ± 7.1		17.1 ± 6.5	12 ± 6	15.2 ± 9		12.7 ± 6.8
200–299	20.9 ± 7.6	16.8 ± 4.2		19.5 ± 6.9	17.9 ± 11	13.3 ± 7.1		16.9 ± 11
300†	15.3 ± 4.2	15.7 ± 5.5		15.5 ± 4.8	14.5 ± 4.9	15.6 ± 8.8		15 ± 6.7
Acculturation*			0.52				0.50	
<2	18.3 ± 5.9	17.1 ± 5.6		17.6 ± 5.7	13.8 ± 7.3	14 ± 6.1		13.9 ± 6.9
2†	23 ± 9.2	15.4 ± 5.5		20.8 ± 9	15.2 ± 8.7	14.9 ± 7.7		15.2 ± 8.4
Season*			<0.0001				0.20	
January–March	13.3 ± 5.2	13.7 ± 4.7		13.6 ± 4.8	11.4 ± 4.5	14.3 ± 5.8		12.6 ± 5.3
April–June	18.3 ± 6.4	17.1 ± 5.1		17.7 ± 5.7	12.1 ± 4.5	15.3 ± 4.7		13 ± 4.8
July–September	21.6 ± 6.9	18.2 ± 4.7		20 ± 6.2	15 ± 8.6	13 ± 6.6		14.4 ± 8.1
October–December	19.3 ± 7	16.7 ± 6.7		17.8 ± 6.8	16.2 ± 8.4	14.6 ± 6.7		15.4 ± 7.6
	Normal	Abnormal		*P*	Normal	Abnormal		*P*
HOMA-IR	19.4 ± 6.9	16.9 ± 5.7		0.01	14.8 ± 8.2	13.1 ± 5.2		0.1
Metabolic syndrome	18.5 ± 6.6	17.1 ± 5.8		0.16	14.9 ± 7.9	12.6 ± 5.1		0.0086
Waist circumference	18.3 ± 6.5	17.4 ± 5.9		0.45	15 ± 8.4	13.1 ± 5.3		0.093
Hypertension	18.1 ± 6.7	18.3 ± 5.8		0.62	14 ± 7.3	14.3 ± 6.8		0.56
Triglycerides	19.2 ± 6.7	16.5 ± 5.6		0.0016	14.3 ± 7.4	13.4 ± 6		0.37
HDL	18.4 ± 6.7	17.8 ± 6.1		0.52	15.4 ± 8.4	12.9 ± 5.4		0.0016
Fasting plasma glucose	19.6 ± 7	17.4 ± 6		0.023	14.4 ± 8	13.7 ± 6.1		0.69
	<7	7 to <9	9†		<7	7 to <9	9†	
A1C	18.3 ± 6.5	14.4 ± 4.4	16.6 ± 4.4	0.2	14 ± 7.2	15.4 ± 6.1	14.6 + 5	0.41

Data are mean ± SD serum 25-OH-D levels expressed as ng/ml. **P* value, of factor adjusted for glycemic status. †Ratio of Arabic meals to total meals consumed in a 1-week period with a higher ratio indicating consumption of more Middle Eastern foods. ‡Cotinine levels <10 ng/ml are considered to be consistent with no active smoking. §Insufficient data. HOMA-IR, homeostasis model assessment of insulin resistance.

OH-D levels and measures of disease status. Analyses were performed using SAS, version 9.1 (SAS Institute, Cary, NC).

RESULTS — The mean age of the subjects was 38 ± 13 years and 39% were men. The mean BMI was 28.4 ± 5.5 kg/m^2. Subjects consumed mostly traditional Middle Eastern foods. The majority of the subjects were inactive or only moderately

physically active (52%). One-third reported smoking cigarettes. Acculturation was low. IR was present in 46%, MS in 33%, and glucose intolerance in 42% of subjects.

Vitamin D insufficiency was present in 75% and hypovitaminosis D in 24%; only four subjects had 25-OH-D levels in the normal range. Serum 25-OH-D levels were lower in women (14.1 ± 7.1) than men (18.1 ± 6.4) ($P < 0.0001$). Only two subjects reported taking vitamin D supplements.

Vitamin D levels as a function of glucose tolerance status and other factors is shown in Table 1. In men, 25-OH-D levels were lower in those with glucose intolerance than in those who were normoglycemic ($P = 0.005$). No such difference was found in women. 25-OH-D levels also varied by season ($P < 0.0001$) and by level of cotinine ($P = 0.04$) in men. Men with IR, hypertriglyceridemia, and glucose intolerance had lower serum 25-OH-D levels than men who were insulin sensitive ($P = 0.01$), had triglycerides <150 mg/dl ($P = 0.0016$), and fasting plasma glucose <100 mg/dl ($P = 0.023$). Decreased 25-OH-D levels were present in women with MS compared with those without MS ($P = 0.0086$). Women with low HDL levels had low 25-OH-D levels compared with those with HDL levels ≥50 mg/dl ($P = 0.0016$).

In men, serum 25-OH-D was negatively correlated with homeostasis model assessment of insulin resistance ($r = -0.19$; $P = 0.0043$), triglycerides ($r = -0.18$; $P = 0.0069$), fasting plasma glucose ($r = -0.15$; $P = 0.027$), and A1C ($r = -0.14$; $P = 0.038$). In women, 25-OH-D was positively correlated with HDL ($r = 0.19$; $P = 0.0008$).

CONCLUSIONS — This study provides population-based estimates of vitamin D status among Arab American and reports associations between 25-OH-D levels and IR, MS, and glucose intolerance. Our findings are similar to those reported from a convenience sample of 87 Arab American women and a representative sample of 6,228 people in the United States (12–13) in whom vitamin D levels were not adequate. 25-OH-D levels have been inversely associated with diabetes in non-Hispanic whites and Mexican Americans, but not in non-Hispanic blacks despite their high prevalence of diabetes and inadequate vitamin D levels (14–15). Our findings in Arab American males are similar to those reported in Hispanic whites and Mexican Americans.

There are several potential limitations to our study. First, factors influencing skin synthesis of vitamin D such as traditional Islamic dress, ultraviolet exposure, and sunscreen utilization and dietary consumption of vitamin D were not assessed. Second, the cross-sectional design of our study limited our ability to examine causal relationships between levels of 25-OH-D and IR, MS, and glucose intolerance.

In summary, the prevalence of inadequate vitamin D levels is high among Arab American men and women. Very few subjects reported taking supplements. In men, lower 25-OH-D levels were associated with IR, components of MS, and glucose intolerance. In women, lower 25-OH-D was associated with lower HDL cholesterol levels. Greater public awareness and interventions to encourage vitamin D consumption are needed in the Arab American community.

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