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Food Cravings, Food Addiction, and a Dopamine-Resistant (DRD2 A1) Receptor Polymorphism in Asian American College Students

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Abstract

Background/Objectives—In an era where obesity remains an important public health concern, food addiction has emerged as a possible contributor to obesity. The DRD2 gene is the most studied polymorphism. The aim of this study was to investigate a relationship between food craving and food addiction questionnaires, body composition measurements, and a dopamine-resistant receptor polymorphism (DRD2 A1) among healthy Asian Americans.

Subjects/Methods—A total of 84 Asian American college students were recruited. Participants underwent body composition measurement via bioelectrical impedance, answered subjective questionnaires, and had blood drawn for genotyping.

Results—Among Asian American college students, there was no difference in body composition (BMI, percent body fat) between the A1 (A1A1 or A1A2) and A2 (A2A2) groups. There were statistically significant differences in food cravings of carbohydrates and fast food on the Food Craving Inventory between the A1 and A2 groups (p=0.03), but not for sugar or fat. Among female Asian college students, there was also a difference on the Power of Food questionnaire (p=0.04), which was not seen among males. 13 out of 55 females also had > 30% body fat at a BMI of 21.4 to 28.5 kg/m^2.

Conclusion—Greater carbohydrate and fast food craving was associated with the DRD2 A1 versus A2 allele among Asian Americans. Further studies examining the ability of dopamine agonists to affect food craving and to reduce body fat in Asian American are warranted. More studies in food addiction among obese Asian Americans are needed with careful definition of obesity, specifically for Asian women.

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Keywords

dopamine; obesity; food addiction; food cravings; Asian American

Introduction

Food addiction, which involves eating behavior, food choice preference, motivation, and hedonic eating, has been increasingly investigated as a possible contributor to obesity. A frequently investigated polymorphism is DRD2 Taq1A A1 allele (rs1800497). This minor allele of the D2 dopamine receptor gene is associated with food addiction and lower density of dopamine receptor in the brain.[1, 2] Altered dopamine receptor expression due to this polymorphism may confer vulnerability to alcohol and drug addiction. The concept of food addiction is that a subset of obese individuals who carry this polymorphism may also overeat to compensate for reduced dopamine signaling. However, there are studies that are contradictory and bring into question the relationship between DRD2 A1 allele, food addiction, and obesity.[3, 4] The differences in age, sex, ethnicity, and sample size may contribute to the inconsistencies.

The majority of studies looking at DRD2 and obesity are done in non-Asian populations (mostly Caucasian). The available literature regarding DRD2 gene in Asian population pertains to other forms of addiction including smoking or alcoholism, not specifically food addiction or obesity.

Given the lack of food addiction research in Asian populations, this study investigates the relationships between DRD2, body measurements, and food addiction questionnaires in an Asian American college student population.

Subjects and Methods

Study Population

Individuals were recruited from a college nutrition class taught at the University of California, Los Angeles. Recruitment took place in February 2014. Table 1 outlines the study population and demographics. Participants were given written informed consent. IRB approval was obtained from the institution. Participants were given food addiction questionnaires, underwent blood draw for genotyping, and had blood measurements obtained. Exclusion criteria included participants with psychiatric history or who took medications affecting appetite including steroids, cyproheptadine, and antipsychotics. None of the participants were excluded. Participants were compensated for their time with a single movie ticket voucher (valued at less than $10.00).

Body Measurements

Participants verbally reported their height in inches and in those that did not know their height, was measured to an accuracy of 1 inch. Body measurements included weight, lean body mass, and fat body mass which were measured by bioelectrical impedance (Tanita

BC-418 segmental body composition analyzer) from which basal metabolic rate and percent body fat (PBF) were calculated. Shoes were removed.

Questionnaires

Food Craving Inventory (FCI): The FCI is a validated self-report measure for cravings of different types of foods.[5] Participants rate frequency of cravings over the past month on 28 food items using the five point Likert scale (0, never; 1, rarely (once or twice); 2, sometimes; 3, often; 4, always/almost every day). FCI consist of foods that can be categorized into sweets (brownies, cookies, candy, chocolate, donuts, cake, ice cream, and cinnamon rolls), high fats (fried chicken, sausage, gravy, fried fish, bacon, corn bread, hot dog, and steak), carbohydrates/starches (rolls, pancakes/waffles, biscuits, sandwich bread, rice, baked potato, pasta, and cereal), and fast food (hamburger, french fries, chips, and pizza). An average score was taken (maximum score 4 for each category).

Power of Food Scale (PFS): The PFS is a validated measure of appetite drive to consume highly palatable food.[6, 7] Scores correspond to hedonic ("liking") hunger motivation and patient susceptibility to the food environment. Participants are provided statements like "I find myself thinking about food even when I'm not physically hungry" and "If I see or smell a food I like, I get a powerful urge to have some." On a scale from 1 ("I don't agree") to 5 ("I strongly agree") a composite score is calculated from the 15 statements (maximum score 75).

Genotyping

Five milliliters of peripheral blood was drawn into EDTA Vacutainer tubes (BD Biosciences, Franklin Lakes, NJ, USA). Plasma and buffy coat were separated by centrifugation for 15 minutes at 2060×g. Genomic DNA was isolated from the buffy coat using the GenElute Mammalian Genomic DNA miniprep kit (Sigma-Aldrich, St. Louis, MO, USA) according to manufacturer's instructions. Participants were genotyped for the Taq I A1/A2 alleles of the DRD2 gene using SNP Genotyping Assay for ANKK1/DRD2 (rs1800497) (Applied Biosystems, Foster City, CA, USA). Real-time PCR was performed using 20 ng of DNA in a 5 μl reaction containing Taqman genotyping master mix and SNP genotyping assay mix (Applied Biosystems). In a 384 well plate reaction mixes were heated to 95°C for 10 minutes followed by 55 cycles of 92°C for 15 seconds then 60°C for 1 minute. Alleles were determined using the allelic discrimination plot in the SDS 2.2.2 software genotyping program on a 7900HT Fast Real-Time PCR system (Applied Biosystems). Each sample was performed in duplicate.

Statistical Analysis

The non-parametric Wilcoxon Rank-Sum test was conducted to compare continuous data including the four FCI scores and the PFS between subjects who have the A1 allele and those who do not. Categorical variables were compared using the Chi-square test. Partial Pearson correlations controlling for sex were conducted to examine the relationship between body composition (BMI, metabolic rate, body fat) as well as hours of TV watched per week with the FCI and PFS. For variables with significant correlations, multiple linear regression was used to further model these relationships. A P-value less than 0.05 was considered statistically significant. All analyses were conducted in SAS version 9.4.

Results

A total of 84 college Asian students participated. Demographics and characteristics of study population can be found in table 1 and 2. 65% of the students were female. All but one participant were nonsmokers.

The prevalence of college students with at least one A1 allele was 63% (table 3). 37% of students were A2A2 genotype. While the majority of students were not considered obese by BMI standards, some could be classified as obese by PBF. 5 out of the 6 females who were categorized as such had at least one copy of A1.

Among Asian college students, there were no statistically significant differences in the frequency of gender, past medical history, transportation usage, exercise behavior, TV watching time, or body composition (BMI) between A1 and A2 groups (table 4).

The A1 group had significantly higher scores for FCI – carbohydrates and fast food (p=0.03) (table 5). There was no difference in PFS between groups (p=0.06). The data was further examined by looking for gender differences. Wilcoxon rank sum analysis was conducted on each sex separately to determine if there were significant differences in PFS between A1 status groups within each sex. For Asian males, mean (s.d.) PFS was 43 (14) in the A1 group vs. 43 (17) in A2 group (no difference, p=0.39), however among Asian females, mean (s.d.) PFS was 46 (12) in the A1 group vs. 41 (13) in the A2 group (significant difference, p=0.04).

The relationship between BMI and PBF among Asian males and females is graphed in figure 1. Both showed a positive linear trend. This supports that there is a correlation between BMI and PBF. Interestingly, none of the female students had BMI greater than 30, yet many had PBF > 30%.

There was no correlation between body composition measurements (i.e. PBF or BMI) and questionnaires (PFS and FCI). There was also no correlation between body composition measurements and genotype.

Discussion

The majority of food addiction research is performed in Caucasian study participants and the studies on Asian Americans specifically are lacking. It is plausible we did not detect a significant correlation between genotype and FCI for high fat and high sugar because the foods chosen for the FCI may be ethnicity dependent. The validation studies for the FCI questionnaire included mostly African American and white participants. For example, culture differences may prevent fried fish, fried chicken, gravy, and cinnamon rolls to be craved among Asian Americans. The studies regarding food addiction utilize these questionnaires routinely. There needs to be consideration regarding the ethnic population being studied prior to making conclusions about food addiction in different populations.

In addition to ethnic considerations, this study also raises the concern of gender differences for food addiction questionnaires. We detected a difference in the PFS score for Asian women between genotype groups (A1 vs. A2) but not for men. The reason for this is unclear but a possibility is that Asian women specifically are more vulnerable to food addiction tendencies if they carry at least one A1 allele. It will be important to confirm this with a larger study, particularly among an obese Asian female population.

Among Asian college students, there was no difference in body composition (BMI, PBF) between the A1 (A1A1 or A1A2) and A2 (A2A2) groups. The relationship between PBF and BMI differs according to ethnicity. It has also been previously reported that BMI may be a poor marker for true obesity among Asian American women. Young Asian women may have normal BMI but actually high PBF.[8] For the same PBF, Chinese subjects have lower BMI than Caucasians.[9] In another study using DEXA to measure PBF, BMI underestimated prevalence of overweight and obesity in Asian-Indian men and women, Asian women, and Hispanic women, whereas BMI overestimated overweight and obesity for African American men and women.[10] This finding was again seen in Vietnamese women[11] and in Asian (Chinese and Korean) children in both China and the United States.[12] In this study, we did not select participants based on BMI or percent body fat. The majority of participants were non-obese as all but one Asian participant had BMI less than 30. See figure 1. However, PBF was higher than 30% in 12 Asian females. All of the Asian males had PBF less than 25%. It should also be pointed out that while none of the Asian females had BMI in the obese range (greater than 30), many had PBF greater than 30%. Future studies should be designed to examine only obese Asians that meet criteria for obesity by PBF and BMI, and more importantly, controls should be chosen by strict criteria as well.

The prevalence of A1 allele depends not only on ethnicity but also characteristics of the population being examined. Blum et al summarizes the vast differences in A1 frequency, citing Yemenite Jews (A1 frequency=0.09), “white controls” (0.19), Chinese (0.47), and Cheyenne (0.8).[13] The prevalence of A1 in whites without diabetes is 29%.[14] In white and black adults with diabetes, the prevalence of A1 is closer to 50%.[15] Among non-Asian (mostly Caucasian) adults with obesity, the A1 allele was present in about 45%.[16] In a study looking at DRD2 in Chinese middle age adults (half of the study participants were obese), there were 70% of individuals with at least one copy of A1.[17] A1 allele appears to be more prevalent in Asian populations. In our study, the prevalence of A1 (A1A1 or A1A2) was 63%. Moreover, when it is further broken down by gender, the female obese individuals (by PBF) have a high prevalence of 83% with at least one copy of A1. This further supports and suggests that the prevalence of A1 depends not only on ethnicity but perhaps also gender.

This study has several limitations. We are only studying one single polymorphism, albeit which has been the most studied “food addiction” gene. Obesity is polygenic, and genes affecting cravings and eating behavior are complex. In this study, the majority of participants had normal BMI. It will be important to further understand the relationship between DRD2, body composition, and food addiction questionnaires among an entirely homogeneous obese Asian population. Another limitation is the population studied is in general healthy without significant proportion of obesity related comorbidities. Nearly all of the students did not meet criteria for obesity by BMI and only a handful did by PBF. We did not find a correlation between questionnaires and body composition perhaps because of the study population. However, it remains plausible that the presence of at least one copy of A1 may predispose to obesity, and that genotype and questionnaire score may be utilized as a marker of food addiction. Future studies of obese Asians are needed to investigate.

Obesity rates continue to rise. A recent study showed that the prevalence of overweight and obesity has increased in children and adolescents in developed countries. Also, China now follows the United States as the country with the second highest number of overweight or obese individuals.[18] There is a need for further studies examining the ethnic and gender differences in food addiction.

In conclusion, while there remains much to be investigated about the role of genetic polymorphisms in an obesogenic food environment, there may exist differences among genders and different ethnic populations. These factors need to be taken into consideration when conducting research studies in food addiction. Further studies to explore the potential role of dopamine agonists to alter food craving and hopefully reduce body fat are warranted.

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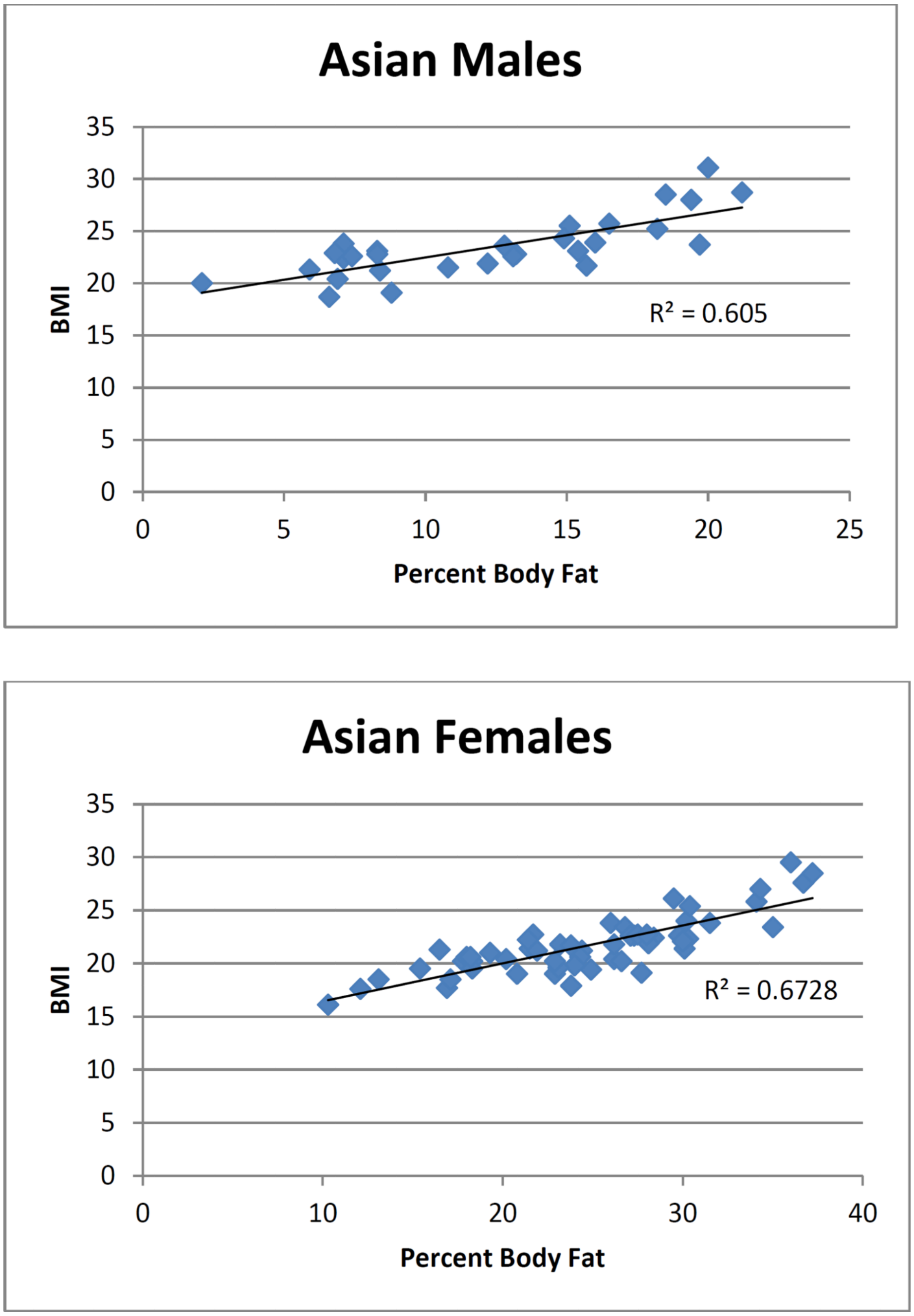

Figure 1.
Relationship between BMI and percent body fat among Asian American males and females

Table 1

Demographics and study characteristics

Variable	**Characteristic**	**N (%)**
Gender	Male	29 (35%)
	Female	55 (65%)
Past Medical History	Diabetes	4 (5%)
	Hypertension	3 (4%)
	High Cholesterol	5 (6%)
	NAFLD	1 (1%)
Transportation	Car	8 (10%)
	Bus	23 (27%)
	Walking	57 (68%)
	Bike	5 (6%)
	Other: skate boarding, scooter	7 (8%)
Smoking	Yes	1 (1%)
	No	83 (99%)
Exercise	Yes	46 (55%)
	No	38 (45%)
DRD2 Genotype	A1A1	11 (13%)
	A1A2	42 (50%)
	A2A2	31 (37%)

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Table 2

Mean participant study characteristics

Variable	Range	Mean (s.d.)
Age	20–26	21 (1)
BMI	16.1–31.1	22.3 (2.9)
% body fat – female	10.3–37.2	24.67 (6.31)
% body fat – male	2.1–21.2	12.29 (5.22)
Metabolic rate (kcal)	1069–2451	1505 (307)
FCI – high fat	0–2.9	0.9 (0.7)
FCI – high sugar	0.1–3.8	1.4 (0.7)
FCI – high carbs	0–3	1.1 (0.8)
FCI – fast food	0–4	1.7 (0.8)
PFS	19–74	44 (13)

Table 3

Genotype Distribution

	n	A1A1/A1A2	A2A2
All Asians Students	84	53 (63%)	31 (37%)
Asian Female	55	35 (64%)	20 (36%)
Asian Female Obese by % Body Fat > 33	6	5 (83%)	1 (17%)
Asian Male	29	18 (62%)	11 (38%)
Asian Male Obese by % Body Fat > 19	4	2 (50%)	2 (50%)

Table 4

Subject Characteristics by Genotype

Variable (n, %)	A1A1/A1A2 (n=53)	A2A2 (n=31)	p-value
Gender – male	18 (34%)	11 (35%)	NS
PMH			
Diabetes	2 (4%)	2 (6%)	NS
HTN	1 (2%)	2 (6%)	NS
High Cholesterol	3 (5%)	2 (6%)	NS
Fatty liver	1 (2%)	0 (0%)	NS
Transportation			
Car	7 (13%)	1 (3%)	NS
Bus	15 (28%)	8 (26%)	NS
Walking	36 (68%)	21 (68%)	NS
Bike	3 (6%)	2 (6%)	NS
Other	5 (9%)	2 (6%)	NS
Exercise – yes	32 (60%)	14 (45%)	NS
TV hours – total	3.4 (2.7)	3.7 (4.5)	NS
BMI (mean, SD)	22 (3)	22 (3)	NS
Metabolic Rate (mean, SD)	1494 (287)	1523 (342)	NS
% body fat(mean, SD)	19.7 (8.7)	21 (7.9)	NS

Table 5

Food Craving and Food Addiction Questionnaires by Genotype

Variable (mean, SD)	A1A1/A1A2 (n=53)	A2A2 (n=31)	p-value
FCI - High Fat	0.69 (0.81)	0.53 (0.81)	0.19
FCI - High Sugar	1.29 (0.77)	1.29 (1.15)	0.33
FCI - Carbohydrates	1.03 (0.93)	0.69 (0.96)	0.03*
FCI - Fast Food	1.85 (0.88)	1.47 (1.02)	0.03*
Power of Food Scale	45 (13)	42 (14)	0.06
Power of Food Scale females only	46 (12)	41 (13)	0.04*
Power of Food Scale males only	43 (14)	43 (17)	0.39