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Diet assessment among men undergoing genetic counseling and genetic testing for inherited prostate cancer: Exploring a teachable moment to support diet intervention

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Abstract

Background: Genetic counseling (GC) and genetic testing (GT) for prostate cancer (PCA) is a rapidly growing, affording opportunity for healthy lifestyle promotion in men aligned with cancer survivorship and cancer prevention goals. We conducted a targeted dietary analysis of men undergoing GC/GT for PCA for adherence to the United States Department of Agriculture (USDA) Food Pattern recommendations which align with preventing cancer and recurrences in the Genetic Evaluation of Men (GEM) study at two academic centers to inform future strategies for diet intervention.

Methods: Participants of GEM with PCA or at-risk for PCA completed a structured food frequency questionnaire indicating number of servings consumed per day or per week of fruits, vegetables, red meat, seafood, processed meat, and foods high in saturated fat. Adherence to the USDA recommendations was assessed for the total sample and by PCA status and aggressiveness, family history, and body mass index (BMI) through χ^2 contingency analyses. One-sample *t* tests

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AUTHOR CONTRIBUTIONS

VNG had access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* VNG, MB, and B-JM. *Acquisition, analysis, or interpretation of data*: VNG, MB, B-JM, EO, LB, LG, and CS. *Drafting of the manuscript:* VNG, MB, B-JM, EO, LB, LG, and CS. *Statistical analysis*: MB.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

were used to compare the dietary behaviors of men to USDA Recommendations. Levels of α were set a priori at $P < 0.05$.

Results: Of 239 males undergoing GC on the study, surveys were completed by 197 men (82.4%), and complete survey data was available on 113 men (47.3%). By the Centers for Disease Control and Prevention BMI classification, 82.3% of the cohort was overweight (45.1%) or obese (37.2%). GEM participants reported consuming less fruits ($P = 0.015$), less vegetables ($P < 0.001$), less seafood ($P < 0.001$), more processed meats ($P < 0.001$), and more foods high in saturated fats ($P < 0.001$) than recommended.

Conclusion: A high proportion of men receiving GC/GT for PCA were overweight and/or obese with lack of adherence to national diet recommendations for cancer risk and recurrence, affording a teachable moment and supporting the systematic focus of introducing nutrition intervention during GC to promote survivorship.

Keywords

diet; genetic counseling; genetic testing; obesity; prostate cancer

1 | INTRODUCTION

According to the American Cancer Society, prostate cancer (PCA) was the most common non-cutaneous cancer diagnosed and the second-leading cause of cancer-related death in men in the United States in 2018.[1] There is increasing recognition of an inherited predisposition for PCA,[2–7] with growing numbers of men engaging in genetic counseling (GC) and genetic testing (GT) to assess inherited risk.[4–7] Before performing GT, best practices have always advocated that patients undergo GC to enhance an informed decision-making process by understanding cancer inheritance, discussing GT (and most recently which combination of genes to be selected in a multigene panel test), reviewing the benefits/risks/limitations of GT, and receiving information regarding implications of test results for themselves and their families.[2,4,8,9] The pretest counseling appointment involves an intake of patients' personal medical history, family cancer history, and risk factors for cancer development (such as diet, smoking, and alcohol intake) and is used to inform GT and risk reduction recommendations. Patients who undergo GT are also encouraged to present for posttest GC to interpret their personal genetic test results and provide cancer screening and risk reduction recommendations to themselves and their families.[8] These GC encounters present opportunities to provide patients with information and recommendations for living a healthy lifestyle, such as addressing obesity, diet, and exercise, to reduce cancer risk and promote survivorship.

Obesity is associated with increased risk for aggressive PCA.[10–15] A dietary pattern contributing to obesity is characterized by few fruits and vegetables, high refined carbohydrates, high total and saturated fats, and intake of cooked red meats.[1,16,17] Healthy dietary habits to reduce PCA risk have been advocated by the American Cancer Society.[16] Furthermore, healthy dietary habits are promoted for cancer survivors by several professional organizations including the American Cancer Society and the National Comprehensive Cancer Network.[18,19] The American Cancer Society Guidelines on nutrition

and physical activity encourage all individuals including survivors to achieve or maintain a healthy weight, engage in regular physical activity, and consume a diet rich in fruits, vegetables, and whole grains.[16,18] Cancer survivors are also encouraged to limit red meat and alcohol intake and avoid consumption of processed meat.[18,20] Given the observation of the association of obesity to PCA risk and comorbid conditions, the analysis of the relationship between food groups, dietary patterns, dietary quality, and PCA has been gaining attention. For example, the Mediterranean diet characterized by high amounts of vegetables, olive oil, complex carbohydrates (high in fiber), lean meats in moderation, and foods containing antioxidants, is consistently recommended for the prevention of cardiovascular disease and obesity.[21] Notably, consumption of fish and other foods containing omega-3 fatty acids (such as walnuts), elements of the Mediterranean diet, have also been associated with a reduction in fatal PCA.[22] Among men diagnosed with nonmetastatic PCA, adherence to a Mediterranean dietary pattern has been associated with lower overall mortality.[22] In contrast, a Western dietary pattern, or a diet characterized by high intake of red meats, processed meats, fried fish, chips and similar snack foods, high-fat milk, and white bread, was associated with a higher risk for PCA.[23] Given the rising amount of data regarding poor diet and obesity with PCA risk, PCA aggressiveness, and negative impact on survivorship, there is a need to gain insights into the landscape of diet profile and obesity among men with PCA undergoing GC, where men may be actively engaged in cancer prevention discussions for potential uptake of diet recommendations. The GC session may provide optimal opportunity to address Mediterranean diet and to study diet interventions in the future if supported by data showing the need to address this issue among men with PCA.

The primary objectives of the present study were to examine obesity status, dietary profile, and dietary adherence to national recommendations for preventing cancer recurrences and promoting survivorship[16,19] among men undergoing GC and GT for inherited PCA. Diet adherence was examined in the context of the United States Department of Agriculture (USDA) Food Pattern recommendations,[24] which align with national dietary guidelines.[16,19] We also assessed differences in dietary intake by PCA status and family history to determine if additional personal or familial factors may inform future dietary interventions at these teachable moments during GC.

2 | MATERIALS AND METHODS

2.1 | Participants

Dietary surveys were completed by participants of the Genetic Evaluation of Men (GEM) study (ClinicalTrials.gov identifier: NCT03076242), a prospective multigene testing study for inherited (PCA) conducted in the context of GC.[2] Detailed recruitment, eligibility for GEM, and study flow have been published previously.[2] Briefly, men with PCA with advanced (T3) or metastatic PCA, early stage PCA with a family history of cancers linked with inherited PCA, or young age at diagnosed (age ≤ 65) are eligible for GEM. Furthermore, men without PCA but at high-risk based upon suspicious family cancer history (suggestive of hereditary breast and ovarian cancer [HBOC] syndrome or Lynch syndrome] or African American males are also eligible for GEM. Participants complete questionnaires

prior to pretest GC that include medical history, family history, diet, physical activity, screening history, and risk factors. After undergoing pretest GC, participants signed informed consent for survey data to be used for research and to proceed with GT. Participants are recruited at Sidney Kimmel Cancer Center (SKCC) at Thomas Jefferson University (TJU), Fox Chase Cancer Center (FCCC), and SKCC Affiliate Hospitals. The GEM study is IRB-approved at all participating institutions.

2.2 | Dietary intake data

Specific survey modules from the GEM Study Lifestyle Questionnaire were used to assess dietary intake of men with or at high-risk for PCA. Participants were asked to indicate the number of servings typically consumed for per day or per week of fruits (cup equivalent), vegetables (cup equivalent), red meat (ounce equivalent), seafood (frequency per week), processed meat (frequency per week), alcohol (drinks per day), and foods high in saturated fat (cup equivalent) and were correlated with the USDA Food Pattern recommendations (Table 1).[16,19,24]

2.3 | Statistical analyses

Descriptive statistics of the total sample and for each subgroup were calculated as means ± standard deviations (SD) for all variables unless otherwise noted. Adherence to the USDA Food Pattern recommendations for servings of fruits, vegetables, red meat, seafood, processed meat, foods high in saturated fat, and alcohol were assessed for the total sample and by PCA status, PCA aggressiveness (Gleason > 7, T3, or metastatic disease), family history, and body mass index (BMI).[25] χ^2 contingency analyses were used in combination with post hoc adjusted residuals to determine whether the self-reported dietary behaviors from the structured lifestyle questionnaire were different in men undergoing GC and GT. One-sample *t* tests were also used to compare the dietary behaviors of men with or at risk for PCA to the USDA Food Pattern recommendations. All statistical procedures were performed using the Statistical Package for Social Sciences (SPSS) version 24.0 with an a priori α level set at $P < 0.05$.[24]

3 | RESULTS

As of July 2017, 239 males presented for GC on the GEM study. Surveys were completed by 197 men (82.4%). After excluding potential outliers and missing values, survey data on 113 men (47.3%) was included in this analysis. Demographic and patient characteristics of the total sample and by PCA status are shown in Table 2. The average age of the cohort was 61.8 ± 8.5 years, and the majority were White males (86.7%). Family history of PCA was reported in 69.0% of the total cohort, while family history of any cancer was reported in 59.3%. There was a significant difference noted in age at consent, marital status, and family history of PCA by PCA status (Table 2).

The mean BMI was 29.2 kg/m^2 and 82.3% of the cohort was either overweight (45.1%), or obese (37.2%) by the Centers for Disease Control (CDC) BMI classification scheme (https://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html). Overall adherence to the USDA guideline for the various groups is shown in Table 3. Significant differences were

noted across all food groups among GEM participants compared with the USDA recommendations. Men in GEM reported consuming less fruits ($P = 0.015$), less vegetables ($P < 0.001$), less seafood ($P < 0.001$), more processed meats ($P < 0.001$), and more foods high in saturated fats ($P < 0.001$) than recommended. There were no statistically significant differences in adherence to USDA Food Pattern recommendations by PCA status (Table S1).

We also conducted exploratory analyses of adherence to the USDA recommendations based upon the family history of PCA and family history of any cancer for potential insights of diet modification recommendations extending from the patient to his family aligned with cancer risk reduction and promotion of survivorship guidelines (Supporting Information Materials). When assessing adherence to the recommendations by family history of PCA, adherence to seafood consumption was significantly different with a higher percentage of adherence among men without a family history of PCA (65.7%) than among men with a family history of PCA (42.3%) ($P = 0.021$) (Table S2). Adherence to processed meat consumption was significantly different by family history of any cancer, with greater adherence among men with a family history of any cancer (47.8%) compared with men with no family cancer history (26.1%) ($P = 0.02$) (Table S3).

4 | DISCUSSION

Obesity is associated with the development of aggressive PCA and consequently an increase in PCA mortality.[10–15] Overall, the findings of published data to date suggest that the consumption of fruits, vegetables, dietary fiber, and omega-3 fatty acids may help prevent the development of PCA and slow disease progression.[25–27] Conversely, consumption of refined carbohydrates, foods high in saturated and trans fats, high-fat dairy, and red meat may promote PCA risk and disease progression.[17] Furthermore, adherence to a Mediterranean diet and maintaining a healthy weight are recommended for cancer survivors to reduce the impact of comorbid conditions such as cardiovascular disease.[18,20,21]

According to the CDC, the incidence of 13 specific cancers can be linked to obesity.[25] These cancers account for 40% of all cancers diagnosed in the United States and, in addition to aggressive PCA, include cancers of the pancreas, kidney, colon and rectum, liver, and multiple myeloma among others.[25] Thus, men with PCA or at high-risk for PCA may also be at risk for other cancers linked with obesity and poor nutrition. Addressing healthful dietary intake for these men is therefore expected to mitigate risk for additional cancers and promote longer-term health benefits such as reducing the risk for cardiovascular disease and diabetes mellitus. Further, several cancers associated with obesity are observed in PCA families, such as breast cancer, uterine cancer, and ovarian cancer often due to common genetic or dietary influences.[2,3,6] Therefore, addressing healthy nutrition and lifestyle with the index patient of a male with PCA would be expected to have a “ripple effect” in families.

GC sessions may present a unique opportunity to address diet and obesity among men with PCA if supported by data demonstrating a need in this understudied setting in a male population. In this cross-sectional investigation, we assessed obesity status overall and compared adherence to dietary recommendations for cancer survivorship among men with PCA and at risk for PCA who have undergone GC and GT in the GEM study. Overall,

82.3% of our cohort was overweight or obese by CDC BMI criteria. Furthermore, the dietary assessment revealed less consumption of fruits, vegetables, and seafood, and more consumption of processed meats and foods high in saturated fats, which are the first data to our knowledge to be reported among men undergoing GC and GT for inherited PCA. Our exploratory analyses by family history revealed lower adherence to consumption of seafood for men with a family history of PCA compared with men without a family history of PCA, supporting a potential role of recommending more seafood (and thus aligning with a Mediterranean diet) for men and their families particularly if there is greater representation of PCA for familial impact. Thus, our data support the need to emphasize diet assessment in the GC session among men with PCA. Our data also support the need to develop diet interventions for future study to be implemented in the GC setting for men with PCA.

Our findings are consistent with recent research. A report from the North Carolina-Louisiana Prostate Cancer Project on saturated-fat intake described that total dietary fat content and dietary fat composition impacted PCA aggressiveness.[28] A higher total fat intake, and a higher ratio of saturated to total fat intake was associated with more aggressive disease at diagnosis (as assessed via Gleason score > 7). Another study reported a significant association between fruit consumption and PCA aggressiveness; fruit intake in men with a Gleason score less than 7 was higher than those with a Gleason score greater than 7.[29] They also reported that nut and fish consumption among men was associated with a protective effect against PCA development. The decreased PCA risk was associated with the highest nut intake categories, and this relationship remained statistically significant after adjusting for covariates.[29] Similarly, the association between fish intake (>50 g) with PCA risk showed a statistically significant trend for reduced risk in both unadjusted and adjusted models.[29] Therefore, our results are consistent with prior studies and lend insight into an opportunity to implement the dietary intervention in the GC context in men undergoing GC and GT for inherited PCA, which is an understudied clinical scenario.

There are some limitations to this study to be noted. Self-reported dietary intake information is subject to measurement error that can result in the underestimation of less healthful foods and an overestimation of healthful foods, such as fruits and vegetables. Participants in this study were asked to recall dietary information for which they “typically” consume. The use of a “typical” diet as a surrogate for past dietary behaviors limits our ability to accurately estimate dietary intake. These data were also collected after diagnosis for participants with PCA and this could possibly bias responses. A validated food frequency tool was not used, and therefore responses had to be categorized and correlated with USDA recommendations. Additionally, participants were not asked about whole grain intake, specifically, and therefore we were unable to compare whole-grain intake to the recommendations for cancer prevention and survivorship. Our BMI results may have therefore been impacted by carbohydrate intake which was not able to be assessed but deserves further study. Furthermore, the relationship between diabetes mellitus, PCA risk and survival, glycemic control, and dietary intake is an important area for continued investigation which may also be addressed in the GC setting pending further data. Finally, while the overall response rate was high (82.4%), the analysis included a subset of participant information due to missing values. Further study is needed to confirm our findings. We also plan to report on a follow-

on analysis focused on physical activity assessment in the GC setting, which is a recognized component to a healthy lifestyle and is not reported here.

In conclusion, to our knowledge, this is the first study to characterize the diet profile and prevalence of obesity among men undergoing genetic assessment for inherited PCA. Our results identify a high rate of obesity among men undergoing genetic evaluation for PCA, supporting the need to perform dietary assessment during GC and develop and study dietary interventions to implement in the GC setting to promote long-term health.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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TABLE 1

USDA food frequency patterns[16,18,19,24]

Dietary components	Recommendation
Fruit (cup eq.)	2.0
Vegetables (cup eq.)	2.5
Red meat (ounce eq.)	1.8
Seafood (frequency per week)	Twice per week
Processed meat (frequency per week)	Limit intake
Foods high in saturated fat (cup eq.)	Limit intake

Abbreviation: eq., equivalent.

TABLE 2

Descriptive characteristics of the overall cohort and by prostate cancer status

	Total (n = 113)	PCA (n = 73)	No PCA (n = 40)	P values
Age at consent, mean ± SD, y	61.8 ± 8.5	63.3 ± 6.8	58.9 ± 10.4	0.02
BMI, mean ± SD, kg/m^2	29.2 ± 5.2	29.7 ± 5.2	28.2 ± 4.9	0.14
BMI, %, kg/m^2				0.31
Normal weight (18.5-24.9)	17.7	13.7	25.0	
Overweight (25-29.9)	45.1	46.6	42.5	
Obese (>30)	37.2	39.7	32.5	
Race, %				0.33
White	86.7	90.4	80.0	
Black	10.6	8.2	15.0	
Asian	1.8	1.4	2.5	
Mixed	0.9	0.0	2.5	
Ethnicity, %				0.94
Hispanic	2.7	2.7	2.5	
Nonhispanic	97.3	97.3	97.5	
Ashkenazi, %	15.9	12.3	22.5	0.37
Education, %				0.42
Less than high school	0.9	1.4	0.0	
High school or GED	10.6	12.4	7.5	
Vocational/technical school	3.5	5.5	0.0	
Some college	8.0	9.6	5.0	
Associate degree	7.1	4.1	12.5	
Bachelor degree	30.1	28.8	32.5	
Graduate degree	39.8	38.4	42.5	
Marital status, %				<0.01
Never married	5.3	1.4	12.5	
Married	80.5	84.9	72.5	

	Total (n = 113)	PCA (n = 73)	No PCA (n = 40)	P values
Living with a partner	2.7	0.0	7.5	
Separated	1.8	1.4	2.5	
Divorced	7.1	11.0	0.0	
Widowed	2.7	1.4	5.0	
Aggressive PCA,[a] %	…	52.1	…	
Family history of cancer, %	59.3	63.0	52.5	0.28
Family history of prostate cancer, %	69.0	58.9	87.5	<0.01

Abbreviations: BMI, body mass index; PCA, prostate cancer.

[a]Aggressive PCA defined as Gleason greater than 7, T3, or metastatic disease.

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TABLE 3

Overall group responses and adherence to USDA recommendations

Groups	USDA recommendations	Participant responses (*n* = 113), mean ± SD	*P* value
Fruits (cup eq.)	2.0	1.69 ± 1.33	0.015
Vegetables (cup eq.)	2.5	1.84 ± 1.27	<0.001
Red meat (ounce eq.)	1.8	0.60 ± 0.76	<0.001
Seafood (frequency per week)	Twice per week	0.68 ± 0.19	<0.001
Processed meat (frequency per week)	Limit intake	1.70 ± 0.63	<0.001
Foods high in saturated fat (cup eq.)	Limit intake	1.36 ± 1.17	<0.001

Abbreviation: USDA, United States Department of Agriculture.