

Research Report

The role of dietary patterns and exceptional parental longevity in healthy aging

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Abstract.

BACKGROUND: Individuals with exceptional longevity and their offspring manifest a lower prevalence of age-related diseases than families without longevity. However, the contribution of dietary habits to protection from disease has not been systematically assessed in families with exceptional longevity.

OBJECTIVE: The aim of this study is to compare dietary patterns between individuals with parental longevity and individuals without parental longevity.

METHODS: Dietary intake was evaluated using the Block Brief Food Frequency Questionnaire in 234 community dwelling Ashkenazi Jewish adults aged 65 years and older who were participants of the LonGenity study, which enrolls the offspring of parents with exceptional longevity (OPEL) and offspring of parents with usual survival (OPUS).

RESULTS: OPEL constituted 38% of the subjects. The two groups had similar daily intake of total calories (1119 vs. 1218 kcal, $p=0.83$), grams of cholesterol (141 g vs. 143 g, $p=0.19$), and grams of sodium (1324 g vs. 1475 g, $p=0.45$), in OPEL vs. OPUS respectively. There were also no significant differences in the intake of other macronutrients, micronutrients, nutritional supplements and consumption of various food groups between OPEL and OPUS after adjustment for age and sex.

DISCUSSION: A healthy diet is associated with a lower risk of several chronic diseases. Our study revealed that dietary intake did not differ between OPEL and OPUS; thus, pointing to the role of longevity genes in protecting from disease among individuals with familial longevity.

CONCLUSION: The offspring of long-lived parents do not differ in their dietary patterns compared to individuals without parental longevity.

Keywords: Diet, longevity, aging, nutrition

1. Introduction

A healthy dietary pattern is associated with reduced overall mortality and disease-specific mortality [1, 2]. In addition to diet, genetic factors also contribute to lifespan, with several familial and twin studies from different populations demonstrating that lifespan is at least partially attributable to genetic factors [3, 4]. Although both genetics and

lifestyle factors, including diet, may affect life-span and health-span, the role of genes has been studied more extensively among families with exceptional longevity. Longevity is a heritable trait, as evidenced by the fact that the parents and siblings of centenarians have longer lifespans compared to the general population [5, 6]. Parental longevity has been associated not only with longer lifespan [6, 7], but also with a reduced burden of multiple diseases among the offspring, including cardiovascular disease, Alzheimer's disease, and cognitive decline [8–10], as well as better physical functioning [11]. Indeed, a number of functional genotypes and genetic signatures are enriched among centenarians [12–17].

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In addition to genetics, the lifestyle factors, including physical activity, dietary habits, smoking, and alcohol consumption have been studied among the exceptionally long-lived [18], but to a much lesser extent. The results of Rajpathak et al. [18] revealed that the exceptionally long-living individuals did not lead a healthier lifestyle throughout most of their lives compared to their contemporaries without longevity. Yet, studies among middle aged individuals suggest that healthy dietary patterns are not only associated with reduced risk for cardiovascular disease and certain cancers, but may also facilitate healthy aging [1, 19–21]. In United States, around half the deaths from heart disease, stroke and type 2 diabetes in 2012 have been attributed to dietary habits [21]. However, the contribution of dietary patterns to exceptional longevity remains unclear. Of further interest is whether the offspring of exceptionally long-lived parents, who also exhibit protection from age-related diseases [6, 22] but who are living at a time of greater emphasis on healthy nutrition by the medical community and the media, display different eating habits in comparison to their peers without parental longevity. This question has not been addressed in the literature and is the focus of our study. Determining the differences or similarities in dietary patterns between the offspring of exceptionally long-lived parents and the offspring of parents without longevity will help us to better understand the contribution of genetics and environment to exceptional longevity.

2. Methods

2.1. Study population

The subjects of this study are participants of the LonGenity study, a longitudinal observational study that began in 2008 with the goal of identifying factors that promote healthy aging and exceptional longevity. The study recruits individuals of Ashkenazi Jewish (AJ) background aged 65 years and older from the Northeastern United States. AJ background was defined as having all four grandparents of AJ descent.

The relative genetic homogeneity of the AJ community increases the power to discover genetic influences [23]. In addition, the AJ population in our study is similar in their education level and socioeconomic status, eliminating some potential confounders that stem from other environmental exposures. The majority of the AJ participants were identified and

recruited using public records such as voter registration lists and a smaller number of participants were recruited through contacts at synagogues, community organizations, and advertisements in Jewish newspapers. The participants were identified either as offspring of parents with exceptional longevity (OPEL; defined as having at least one parent who lived to age 95 or beyond) or as offspring of parents with usual survival (OPUS; defined as having neither parent survive to age 95). Subjects were assessed with physical evaluations that included measures of height and weight. Body mass index (BMI) was calculated according to the formula: $BMI = \text{weight in kg}/(\text{height in m})^2$. Informed consent was obtained from all participants and the study was approved by the Albert Einstein College of Medicine Institutional Review Board.

2.2. Dietary data

Nutritional data was obtained using the Block Brief Food Frequency Questionnaire (FFQ) 2000. This questionnaire was devised based on a validated reduced dietary questionnaire developed by Block et al. [24]. Approximately 70 food items were included in the Block Brief FFQ 2000 and the participants were required to recall the quantity and frequency of weekly intake of various foods and supplements over the past year. The nutrient data was extracted from the questionnaires by Nutrition Quest, Berkeley, California and data output was comprised of daily intake of macronutrients and micronutrients. It also included the daily intake of various food items and food groups, which were created based on a nutritional intake study performed in the Third National Health and Nutrition Examination Survey (NHANES III) and NHANES 1999–2000 [25]. The Block Brief FFQ 2000 was completed by the first 234 participants that were recruited into LonGenity.

2.3. Statistical analysis

The characteristics of the study population and dietary intake were summarized with descriptive statistics. The continuous variables were analyzed with parametric and non-parametric tests, when indicated, and the results were presented as means and standard deviations (SD) for normally distributed data and as medians and interquartile range (IQR) for non-parametric data. Chi-square test or Fischer Exact test, when appropriate, was used to analyze

Table 1
Subject characteristics and daily nutritional intake among OPEL and OPUS

Characteristics	OPEL (n = 89) Mean (SD)	OPUS (n = 145) Mean (SD)	p-value	
Females (%)	65	57	0.19	
Age (years)	75 ± 5	79 ± 7	<0.01	
Height (m)	1.6 ± 0.1	1.6 ± 0.1	0.48	
Weight (kg)	72 ± 17	73 ± 13	0.62	
BMI (kg/m ²)	28 ± 5	29 ± 5	0.16	
Nutrient intake per day	OPEL (n = 89) Median (IQR)	OPUS (n = 145) Median (IQR)	p-value	Adjusted p-value ¹
Total calories (Kcal)	1119 (906–1520)	1218 (940–1553)	0.30	0.83
Total carbohydrates (g)	145 (102–190)	156 (118–206)	0.14	0.33
Total protein (g)	46 (32–63)	47 (35–63)	0.82	0.87
Total fat (g)	44 (31–55)	45 (34–62)	0.36	0.87
Total alcohol (g)	2 (0.6–9)	1 (0.1–4)	0.018	0.118
Sugars (g)	74 (54–112)	84 (62–118)	0.13	0.34
Saturated fat (g)	12 (10–19)	15 (11–20)	0.28	0.85
MUFA (g)	17 (12–23)	18 (13–23)	0.68	0.73
PUFA (g)	8 (6–12)	9 (7–13)	0.26	0.41
Trans fat (g)	1 (0.8–2)	1 (0.9–2)	0.37	0.62
Cholesterol (mg)	141 (104–216)	143 (98–197)	0.41	0.19
Sodium (mg)	1324 (1000–1856)	1475 (1066–1910)	0.14	0.45
Calcium (mg)	493 (412–735)	587 (433–815)	0.10	0.92
Iron (mg)	8 (6–13)	9 (7–11)	0.96	0.20
Vitamin A (IU)	9010 (4998–13426)	8880 (5450–18176)	0.39	0.60
Carotenoids (µg)	15057 (8339–21258)	16706 (8854–29216)	0.09	0.25
Vitamin D (IU)	91 (50–175)	84 (45–163)	0.61	0.84
Vitamin E (IU)	7 (5–10)	7 (5–10)	0.79	0.20
Vitamin K (µg)	150 (89–240)	130 (79–239)	0.52	0.52
Vitamin B1 (mg)	1 (0.7–1.4)	1 (0.8–1.3)	0.41	0.59
Vitamin B2 (mg)	1 (0.9–1.7)	1.2 (1–2)	0.61	0.34
Vitamin B12 (µg)	2.5 (2–4)	3 (2–4)	0.69	0.06
Folate (µg)	256 (200–356)	255 (201–355)	0.97	0.34
Vitamin C (mg)	120 (82–172)	124 (80–182)	0.52	0.49
Caffeine (mg)	1 (0–3)	2 (0–7)	0.06	0.02
Dietary fiber (g)	13 (9–18)	14 (10–18)	0.25	0.40

¹Adjusted for age and sex.

categorical data. Multivariable adjusted regression analyses were performed to test the associations between the OPEL or OPUS status and the intake of various dietary components, adjusted for age and sex. The *p*-value of <0.05 was considered to be statistically significant. Data analysis was performed using SPSS version 12.0 (SPSS Inc. Chicago, IL).

3. Results

The characteristics of the study subjects and the daily nutritional intake in the two groups are presented in Table 1. Of the 234 participants, 38% were OPEL. The OPEL group was also slightly younger and included a larger percentage of women than the

OPUS group; therefore, all dietary analyses were adjusted for sex and age.

3.1. Daily nutritional intake (Table 1)

The OPEL and OPUS did not significantly differ in their daily intake of total calories, grams of carbohydrates, proteins, fats or dietary fiber. There were also no significant differences between the two groups in their daily intake of sugars, sodium, saturated fats, mono-unsaturated fats (MUFA), poly-unsaturated fats (PUFA), and cholesterol. The two groups had similar daily intake of fat-soluble and water-soluble vitamins and various minerals. However, the OPUS consumed more caffeine daily than the OPEL, a difference that remained significant even

Table 2

Percentage of individuals in each group who reported supplement intake

Supplement intake	OPEL (%)	OPUS (%)	<i>p</i> -value	Adjusted <i>p</i> -value ¹
Vitamin A	63	67	0.54	0.46
Vitamin B1	65	66	0.96	0.75
Vitamin B2	65	66	0.96	0.75
Vitamin B3	65	66	0.96	0.75
Vitamin B6	65	66	0.96	0.75
Folate	73	70	0.58	0.68
Vitamin B12	65	66	0.96	0.75
Vitamin C	75	70	0.41	0.49
Vitamin D	79	77	0.71	0.89
Vitamin E	74	69	0.40	0.51
Beta carotene	70	68	0.74	0.93
Calcium	80	75	0.48	0.62
Magnesium	62	64	0.72	0.51
Copper	62	64	0.72	0.51
Zinc	64	66	0.74	0.55
Iron	63	66	0.61	0.45

¹Adjusted for age and sex.

after adjustment for age and sex, 2 mg (0 mg–7 mg) vs. 1 mg (0 mg–3 mg), $p = 0.02$.

3.2. Supplement intake (Table 2)

The intake of vitamin and mineral supplements did not differ between the OPEL and OPUS groups.

3.3. Daily consumption of each food group (Table 3)

After adjustment for age and sex, the OPEL and OPUS consumed similar amounts of food from each of the food groups, except for wine and wine coolers that were consumed in higher amounts by the OPEL than the OPUS, 13 g (3 g–75 g) vs. 12 g (3 g–50 g), $p = 0.01$. Notably, there were no significant differences in the daily consumption of fruits, vegetables, sweets, desserts, fast foods, meats, fish, olive oil or canola oil between the two groups.

4. Discussion

This study found that there were no significant differences in the dietary patterns overall and the intake of calories, macronutrients or micronutrients between OPEL and OPUS. These results are consistent with our prior study, which demonstrated that individuals with exceptional longevity did not follow

a particularly healthy or a special diet [18]. Our findings support the notion that exceptional longevity is primarily genetically determined and that genes associated with longevity may protect individuals from the impact of environmental exposures [6, 26]. Thus, the rare individuals with long-lived parents may have a longer and healthier life despite having dietary patterns that are similar to the offspring of parents without longevity.

The beneficial effects of certain diets, like the Mediterranean diet, have been extensively studied [19, 20, 27] and have been associated with reduced risk of overall and cardiovascular-specific mortality [19, 28], cancer and neurodegenerative diseases [28]. The Mediterranean diet mainly consists of vegetables, fruits, seeds, nuts, bread, low to moderate consumption of cheese, yogurt, fish, poultry and wine and a low consumption of red meats, with olive oil being the major source of fat [29]. On the contrary, high intake of sodium, processed meat and sugar-sweetened beverages have been associated with increased cardiometabolic-specific mortality [21]. Our study showed that the OPEL and OPUS consumed similar quantities of vegetables, fruits, bread, cereals, meats, fish and olive oil. Also, there were no differences found in the intake of sodium, meats and sugary drinks between the two groups.

Not only did the OPEL and OPUS consume similar quantities of various foods, but both groups actually consumed many nutrients in the recommended amounts. The United States dietary guidelines recommend a daily consumption of less than 2.3 grams of sodium [30] and both groups in our study consumed reduced amounts of sodium. On the other hand, the daily caloric contribution from sugars was more than 2.5 times the upper limits of dietary guidelines in both the groups [30]. Yet, the quantity of sugars consumed daily by OPEL and OPUS was similar to the average daily added sugar intake in the United States [31]. These findings suggest that both OPEL and OPUS followed many healthy eating practices and in some instances had dietary intake that was similar to the intake of the general United States population. This highlights the fact that genetic mechanisms likely play a principal role in longevity and protection from age-related diseases [32] and that the role of dietary habits is probably less important in this unique cohort.

Even though the consumption of most nutrients and food groups was similar between the OPEL and OPUS, statistically significant differences in the intake of certain dietary components were noted between the two groups. While OPEL

Table 3
Daily consumption in grams of each food group among OPEL and OPUS

Food group (grams/day)	OPEL	OPUS	<i>p</i> -value	Adjusted <i>p</i> -value ¹
	Median(IQR)	Median(IQR)		
Eggs or egg biscuits	14 (4–29)	14 (3–25)	0.41	0.23
Cooked cereal or grits	8 (0–51)	17 (0–86)	0.22	0.08
Cheese and cheese spreads	6 (3–18)	12 (2–18)	0.22	0.30
Yogurt and frozen yogurt	18 (2–53)	18 (2.02–53)	0.51	0.82
Bananas	17 (4–52)	34 (9–60)	0.12	0.65
Apples or pears	21 (8–60)	30 (10–60)	0.96	0.83
Oranges, tangerines	9 (2–37)	10 (2–37)	0.91	0.89
Other fresh fruits	37 (12–68)	37 (12–79)	0.80	0.76
White potatoes, baked or mashed	7 (3–17)	13 (4–27)	0.06	0.32
Sweet potatoes	3 (2–11)	7 (2–14)	0.23	0.24
Rice or dishes with rice	7 (3–13)	6 (1–13)	0.13	0.73
Baked peas, blackeye peas, pintos	2 (1–5)	3 (1–7)	0.20	0.28
Green beans or peas	5 (2–17)	5 (2–19)	0.54	0.90
Broccoli	13 (5–26)	13 (4–26)	0.71	0.25
Carrots	11 (3–22)	11 (3–34)	0.26	0.59
Spinach (cooked) or greens	7 (3–14)	6 (1–13)	0.05	0.31
Coleslaw and cabbage	3 (1–9)	2 (1–9)	0.50	0.96
Green salads	51 (20–102)	51 (20–102)	0.34	0.12
Raw tomatoes	27 (9–49)	27 (13–62)	0.28	0.21
Other vegetables	13 (5–39)	13 (3–26)	0.28	0.93
Vegetable soup	17 (4–35)	35 (4–70)	0.15	0.06
Hamburger and cheeseburger	2 (1–10)	2 (1–10)	0.85	0.74
Mixed dishes with beef and pork	4 (2–18)	3 (0–9)	0.02	0.07
Fish (not fried)	24 (12–37)	12 (6–24)	<0.01	0.30
Hot dogs or dinner sausage	1 (1–3)	1 (0–3)	0.82	0.97
Pizza	2 (1–6)	2 (1–6)	0.91	0.88
Bagels, English muffins, buns	3 (1–11)	6 (1–12)	0.26	0.64
White bread	2 (0–7)	1 (0–7)	0.15	0.59
Dark bread	16 (3–24)	16 (4–24)	0.34	0.24
Doughnuts, pastry	5 (1–17)	5 (1–17)	0.57	0.83
Cookies	2 (1–8)	4 (0–12)	0.43	0.44
Ice cream	5 (2–19)	4 (1–19)	0.20	0.75
Chocolate candy, candy bars	2 (1–7)	3 (0–14)	0.51	0.44
Sugary drinks	183 (8–258)	249 (19–275)	0.15	0.32
Reduced fat 2% milk	0 (0–11)	0 (0–11)	0.90	0.87
Beer	0 (0–6)	0 (0–6)	0.14	0.22
Wine or wine coolers	13 (3–75)	12 (3–50)	0.03	0.01
Liquor or mixed drinks	2 (0–12)	0 (0–5)	0.23	0.43
Olive oil, canola oil	1 (0.5–7)	1 (0–7)	0.18	0.38

¹Adjusted for age and sex.

consumed more daily grams of alcohol than the OPUS, the difference was not statistically significant after adjustment for age and sex; yet, a statistically significant difference was noted in the grams of wine and wine coolers consumption, with OPEL consuming higher quantities. A standard drink of wine measures 4 ounces (113 grams) and contains 13% alcohol, which equates to 12.5–15 grams of pure alcohol per drink [33]. The Block Brief FFQ 2000 provided data on total gram consumption of both wine and wine coolers, which have a lower alcohol content than wine. Hence, the median daily consumption of

grams of wine or total alcohol in both groups was lower than a standard drink of wine, which would qualify as low intake [33]. We also noted a higher consumption of caffeine among the OPUS in our study. Caffeine amounts of 32 mg or below are considered to be low and are less than the amount contained in a cup of coffee [34]. Therefore, the caffeine and wine intake in both groups of our cohort was relatively low and unlikely to be of clinical significance.

Although the present and past [18] studies do not suggest that dietary patterns influence exceptional longevity, the contribution of dietary habits and other

lifestyle factors to health is likely more substantial among individuals without genetic predisposition to exceptional longevity. A study conducted by Khera and colleagues [35] demonstrated that lifestyle factors, including dietary patterns, were associated with susceptibility to coronary artery disease and their association was independent of genetic risk factors. However, while this study found that healthy lifestyle habits were associated with an almost 50% reduction in the relative risk of coronary artery disease among individuals at high genetic risk, the risk reduction was much lower among those at low genetic risk, highlighting the importance of gene-environment interactions. Thus, it follows that individuals with genetic predisposition to exceptional longevity and their offspring have lesser risk of coronary artery diseases, strokes, hypertension, and cancer [6, 22], independent of dietary patterns.

Numerous genetic and molecular markers have been identified to be associated with exceptional longevity [13, 14, 36–41]. Whether these markers protect against the harmful effects of an unhealthy diet or provide the beneficial effects of a healthy diet are yet to be elucidated. Genetic factors are believed to slow the rate of aging and protect against single or a composite of age-related diseases. Therefore, even in the setting of an unhealthy diet the longevity genes may protect the individual from its effect and significantly delay its negative influence. Clearly some diets are protective against cardiovascular disease and cancer [2] regardless of genetic background. These include diets that are rich in fruits, vegetables, nuts/seeds, fish, and olive oil, moderate in alcohol consumption, and low in the intake of sodium, saturated fats, sugar and meat [21, 27, 42]. The proposed protective mechanisms of such healthy dietary habits include reduction of free radical generation by antioxidant molecules which moderate enzymes in xenobiotic pathways, inhibition of platelet aggregation, regulation of the immune system, modulation of cholesterol synthesis and transport pathways, and prevention of endothelial dysfunction among others [43–45], which are all consistent with the protective mechanisms against aging.

The strengths of our study include having two groups that are distinct in their parental longevity. Moreover, the study population is ethnically and socioeconomically homogeneous, which is advantageous for the study of environmental and genetic interactions. Our study also has several limitations. Since the nutrition data collection depended on dietary recall over the past one year, the possibility

of recall bias exists. The data output provided by the questionnaire sometimes groups foods together and thus does not permit for analysis of individual food components, as is the case for wine or olive oil. Also, due to the reduced list of food items in the Block Brief FFQ 2000, there is underestimation of macronutrient and caloric intake. However, the Block Brief FFQ 2000 does not underestimate the intake of most micronutrients [24]. As we compared relative measures between the two groups using the same research tools, the underestimations are not likely to be differential between the two groups and thus, are unlikely to have influenced the inferences. The lack of measurement of dietary biomarkers that may complement the self-reported data from the Block Brief 2000 is another potential limitation.

In conclusion, the results of our study demonstrate that the offspring of long-lived parents, who have been previously shown to enjoy a relatively disease-free life, display dietary habits that are not different from those without parental longevity, who have a higher prevalence of most age-related diseases.

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