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Plant-based, fast-food, Western-contemporary, and animal-based dietary patterns and risk of premature aging in adult survivors of childhood cancer: a cross-sectional study

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Abstract

Background Although premature aging is a significant concern in adult survivors of childhood cancer, little is known about the role of diet in premature aging in this vulnerable population. Therefore, we examined whether dietary patterns specific to childhood cancer survivors are associated with premature aging.

Methods This cross-sectional study included 2904 adult survivors of childhood cancer (mean age = 31 years, SD = 8 years) in the St. Jude Lifetime Cohort. Diet was assessed using a food frequency. Four dietary patterns were identified: (1) plant-based diet pattern high in whole grains, fruit, and vegetables; (2) fast-food diet pattern high in processed meat, high-fat dairy, and sweets and desserts; (3) Western contemporary diet pattern high in red meat, pasta/rice, French fries, and salty snacks; and (4) animal-based diet pattern high in all meats. The deficit accumulation index (DAI), a proxy measure of premature aging, was estimated as the ratio of the number of age-related items out of 44 total conditions and categorized into low, medium, and high deficit accumulation groups. Multivariable multinomial logistic regressions were used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) of medium and high DAI groups (reference: low group).

Results Compared to survivors consuming a plant-based diet, those who consume a fast-food ($OR_{high\ vs.\ low\ DAI} = 1.82$, 95% CI: 1.12–2.96), a Western contemporary (OR = 2.12, 95% CI: 1.31–3.43), or an animal-based diet (OR = 2.10, 95% CI: 1.15–3.84) had approximately a twofold higher odds of being in the high DAI group. In contrast, survivors with a plant-based diet had almost 50% lower odds of being in the high DAI group, compared to those with other dietary patterns (OR ranges 0.47–0.55).

Conclusions A plant-based diet may promote healthy aging, whereas a fast-food, a Western contemporary, and an animal-based diet may have detrimental effects on aging. Adult survivors of childhood cancer may benefit from nutrition education and interventions for healthy aging.

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Keywords Dietary patterns, Premature aging, Deficit accumulation index, Childhood cancer survivor, Plant-based diet, Fast-food diet, Western-contemporary diet, Animal-based diet

Background

Survival rates for childhood cancer have significantly improved over the past decades, resulting in a growing number of survivors [1]. Nonetheless, as long-term survivors age, they face a variety of long-term health challenges [2]. Notably, compared to their peers who have never had childhood cancer, childhood cancer survivors have a higher prevalence of aging-related chronic health conditions, frailty, cognitive impairment, and excess risk for mortality, a sign of premature aging [3–5].

Modifiable lifestyle factors play a crucial role in the aging process. In the general population, a diet rich in vegetables and fruits and moderate consumption of animal-based foods has been associated with longer telomeres and slower epigenetic age acceleration [6–8]. However, the role of diet in aging in adult survivors of childhood cancer, whose cancer treatments may already have a detrimental impact on aging, is not known [4, 9]. In our previous studies, we found that intakes of some plant foods, such as dark green vegetables and nuts and seeds, were related to a lower risk of premature aging, whereas sugar and sugar-sweetened beverage consumption was related to an increased risk of premature aging [10, 11]. However, these studies did not provide the full picture of the role of diet in aging. Since we often eat meals and snacks consisting of a variety of foods and nutrients, there are potential synergies that occur when foods and nutrients are consumed together. Therefore, we investigated whether dietary patterns that have been uniquely identified in childhood cancer survivors were associated with the accumulation of health deficits, a proxy measure of premature aging, in a large cohort of adult survivors of childhood cancer.

Methods

Study design and participants

The St. Jude Lifetime Cohort Study (SJLIFE) was established to study the long-term health outcomes of childhood cancer survivors [12]. The study enrolled participants treated at St. Jude Children's Research Hospital and who survived for more than 5 years following their cancer diagnosis. Consented participants complete self-administered health surveys assessing demographics, lifestyle, health behaviors, and psychosocial outcomes and undergo periodic comprehensive multi-system clinical evaluations. Written informed consent was obtained. The study is approved by the St. Jude Children's Research Hospital Institutional Review Board.

For the current study, we included adult survivors (aged ≥ 18 years) enrolled in SJLIFE between 2007 and 2017 ($n=4079$). We excluded survivors who did not complete dietary assessments ($n=234$), those who were missing information on dietary portion size ($n=418$) or reported extreme energy intake (< 600 or > 5000 kcal/day, $n=232$), pregnant women ($n=42$), individuals who had records that precluded assignment of sex ($n=3$), or those who had insufficient information to calculate a deficit accumulation index (DAI) ($n=246$). The excluded survivors tended to be younger, non-White, not report education level, and had cancer in central nervous system compared to the analytic cohort. The final analytic cohort included 2904 adult survivors of childhood cancer.

Dietary pattern assessment

Diet was assessed using a 110-item Block food frequency questionnaire (FFQ) previously validated using 24-h recalls [13]. Participants were asked to report the frequency of their food intake, choosing from nine categories ranging from "never" to "every day," and also specify portion sizes for each item. Food pictures were provided to aid in estimating portion sizes. The FFQ also asked about the use of multivitamins and single supplements. Nutrient intake calculations were based on the USDA Food and Nutrient Database for Dietary Studies.

Four dietary patterns were examined in the study: (1) a plant-based pattern characterized by greater intake of whole grains, fruit, vegetables, nuts and seeds, low-fat dairy, and non-fried fish; (2) a fast-food pattern characterized by greater intake of high-fat dairy, processed meat, sweets and desserts, and sugar-sweetened beverages; (3) a Western contemporary characterized by greater intake of pasta/rice, French fries, red meat, and salty snacks; and (4) an animal-based pattern had greater intake of all meats, including poultry and fish, high-fat dairy, and legumes (Additional file 1: Table S1). Details of the dietary pattern identification have been described previously (Additional file 1: Method S1) [14]. Briefly, the individual food items in the FFQ were grouped into 48 food categories based on similar nutrient contents or culinary uses. First, factor analysis was performed using these 48 predefined food groups to identify foods that were typically consumed together. Subsequently, cluster analysis, using energy-adjusted factor scores, was

performed to classify survivors into mutually exclusive dietary patterns.

Deficit accumulation index

Premature aging was assessed using the DAI, which takes into account 44 aging-related health conditions [15]. These conditions encompass chronic health issues, physical and psychosocial impairments, as well as difficulties in performing daily activities (Additional file 1: Table S2). Survivors with more than 10% missing items were excluded from the analysis. Each item was assigned a score, ranging from 0 (indicating absence) to 1 (indicating presence and/or the most severe condition), and these scores were then summed and divided by the total number of items examined. This calculation resulted in the DAI, which ranges from 0 to 1 and represents the proportion of deficits out of a possible 44 items. The DAI was categorized into three groups: low (< 0.2), medium (0.2 to < 0.35), and high (≥ 0.35) deficit accumulation groups based on cut-points that were associated with mortality in SJLIFE and other studies [15, 16].

Other risk factor assessment

Information on demographic factors (e.g., age, sex, race/ethnicity), lifestyle (e.g., smoking), and health behaviors was collected through self-administered questionnaires. Neighborhood-level socioeconomic disadvantage was assessed using the area deprivation index, which incorporates factors such as education levels, employment rates, housing quality, and poverty indicators at the census block level; higher scores indicate greater levels of deprivation [17]. Cancer diagnosis and detailed treatment information (e.g., cumulative chemotherapy and region-specific radiotherapy doses) were obtained from medical records.

Statistical analysis

Multinomial logistic regressions were used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for the associations between dietary patterns and DAI categories. The low DAI group (DAI < 0.2) was used as a reference. Age-only and multivariable-adjusted analyses were performed. Multivariable models were adjusted for a priori selected potential confounders—age, sex (female and male), race/ethnicity (non-Hispanic white, non-Hispanic black, and Hispanic or other), education (less than high school, high school graduation, training after high school, and college or post-grad), area deprivation index (quartiles and unknown), smoking (never, former, and current), multivitamin use (yes and no), single supplement use (yes and no), platinum-based chemotherapy, other chemotherapy, chest radiation, cranial radiation, and other radiation (yes and no). Analyses stratified by age (< 30 and ≥ 30 years; based on median), sex (male and female), race (non-Hispanic Whites and others), area deprivation index (above/below median), smoking (never/ever), age at cancer diagnosis (< 10 and ≥ 10 years; based on median), cancer type (leukemia, lymphoma, others), and cancer treatments (radiation and chemotherapy) were also performed. All analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC).

Results

The average age of childhood cancer survivors was 31 years (SD: 8); 53% were male and 84% non-Hispanic White (Table 1). The majority represented survivors of leukemia (37%) or lymphoma (19%). The most common dietary pattern was the fast-food diet (36%), followed by the Western contemporary diet (29%), the plant-based diet (21%), and the animal-based diet (14%). Twenty and eight percent of survivors had a medium or high DAI, respectively. Survivors consuming a plant-based diet were more likely to be older, female, have higher educational attainment, live in less deprived areas, and have healthier behavior. In contrast, survivors consuming a fast-food diet were more likely to be male, smokers, and have lower education, while those consuming a Western contemporary diet tended to be non-Hispanic White. The animal-based diet consumers tended to be younger, male, and non-White. Survivors who had lymphoma were more likely to have the plant-based diet pattern than other survivors, whereas those who had cancer in central nervous system were less likely to have the plant-based diet pattern but more likely to have the animal-based diet pattern. The prevalence of dietary patterns did not differ by cancer treatment history.

In age-adjusted models, compared to a plant-based diet, the other three dietary patterns—fast-food, Western contemporary, and animal-based diets—are associated with an increased risk of premature aging, as measured by DAI (Additional file 1: Table S3). After controlling for confounders in multivariable models, the associations were attenuated, but remained statistically significant (Table 2). Compared to survivors consuming a plant-based diet, those consuming a fast-food, Western contemporary, or animal-based diet had approximately a twofold higher odds of being in the high DAI group: multivariable $OR_{\text{high vs. low DAI}}$ was 1.82 (95% CI: 1.12–2.96) for a fast-food diet, 2.12 (95% CI: 1.31–3.43) for a Western contemporary diet, and 2.10 (95% CI: 1.15–3.84) for animal-based diet. Conversely, survivors with a plant-based diet, compared to survivors with a fast-food, a Western contemporary, or an animal-based diet, had almost 50% lower odds of being in the high DAI group (OR = 0.47–0.55). When the fast-food, Western contemporary, and animal-based diet were compared

Table 1 Participants' characteristics by dietary patterns in adult survivors of childhood cancer: St. Jude Lifetime Cohort Study ($n = 2904$)

	Total	Plant-based diet	Fast-food diet	Western contemporary diet	Animal-based diet	*p* value[a]
n	2904	617	1046	843	398	
Age (years, mean)	31.3	32.2	31.3	31.2	29.9	< 0.001
Sex (%)						< 0.001
Female	46.9	66.9	32.4	50.2	37.9	
Male	53.1	33.1	67.6	49.8	62.1	
Race/ethnicity (%)						< 0.001
White-non-Hispanic	83.6	89.3	81.2	91.7	63.8	
Black-non-Hispanic	12.7	5.8	16.2	6.5	27.1	
Others[b]	3.8	4.9	2.7	1.8	9.0	
Education[c] (%)						< 0.001
Less than high school	8.2	3.2	10.0	9.0	9.5	
High school graduate	18.2	9.2	21.1	19.5	21.6	
Training after high school	33.1	27.1	35.3	34.8	33.4	
College or post- graduate	33.1	52.4	26.3	30.4	26.6	
Other[d]	3.1	3.6	2.8	3.2	3.3	
Area deprivation index[e] (%)						< 0.001
Quintile 1	22.1	34.7	19.8	17.3	19.1	
Quintile 2	22.2	22.2	22.2	24.4	17.6	
Quintile 3	22.8	17.8	24.6	25.9	19.1	
Quintile 4	22.5	12.8	23.6	24.4	30.4	
Unknown	10.4	12.5	9.8	7.9	13.8	
Smoking[c] (%)						< 0.001
Never	68.4	75.9	65.0	68.0	66.8	
Former	7.7	5.5	9.1	7.6	7.8	
Current	16.0	9.4	18.9	17.1	16.3	
Multivitamin use (%)	26.7	40.8	23.9	22.9	20.1	< 0.001
Single supplement use (%)	38.6	55.8	34.3	33.6	33.9	< 0.001
Cancer group						
Central nervous system (%)	11.5	9.2	12.0	11.0	14.3	0.082
Leukemia (%)	36.6	35.2	34.9	39.4	37.4	0.188
Lymphoma (%)	18.9	23.7	18.4	17.4	15.8	0.005
Other (%)	33.1	31.9	34.7	32.1	32.4	0.411
Cancer treatment						
Platinum-based chemotherapy (%)	12.5	11.3	12.7	11.9	14.8	0.38
Other chemotherapy[f] (%)	85.5	86.2	84.8	85.6	85.7	0.874
Chest radiation (%)	23.5	25.1	22.4	23.6	23.4	0.782
Cranial radiation (%)	33.1	34.2	33.0	33.1	31.7	0.648
Other radiation[g] (%)	31.2	30.0	31.5	30.8	32.9	0.782
DAI						< 0.001
Low	71.6	77.8	70.0	70.5	68.3	
Medium	20.0	17.5	21.0	18.7	23.9	
High	8.4	4.7	9.0	10.8	7.8	

[a] χ^2 test was used to compare categorical variables and ANOVA was used to compare continuous variables

[b] Other included Hispanic, Indian or Alaskan Native, Asian, and Pacific Islander

[c] Numbers may not add up to 100% due to missing

[d] Other included some college and no applicable

[e] Higher the index, the more deprived areas

[f] Other chemotherapy included alkylating agent, anthracycline, and any other chemotherapy

[g] Other radiation included neck radiation, abdomen radiation, spine radiation, and other radiation

Table 2 Multivariable-adjusted[a] odds ratios and 95% confidence intervals of deficit accumulation index (DAI) categories by dietary patterns in the St. Jude Lifetime Cohort Study ($n = 2904$)

	Plant-based diet	Fast-food diet	Western contemporary diet	Animal-based diet
Low DAI ($n = 2078$)	1.00 (Ref.)			
Medium DAI ($n = 581$)	1.00	1.30 (0.97–1.73)	1.16 (0.86–1.57)	1.56 (1.09–2.23)
High DAI ($n = 245$)	1.00	1.92 (1.18–3.11)	2.29 (1.41–3.69)	2.12 (1.16–3.86)
Low DAI ($n = 2078$)		1.00 (Ref.)		
Medium DAI ($n = 581$)	0.77 (0.58–1.03)	1.00	0.90 (0.70–1.15)	1.20 (0.89–1.63)
High DAI ($n = 245$)	0.52 (0.32–0.85)	1.00	1.19 (0.85–1.68)	1.11 (0.69–1.77)
Low DAI ($n = 2078$)			1.00 (Ref.)	
Medium DAI ($n = 581$)	0.86 (0.64–1.16)	1.12 (0.87–1.43)	1.00	1.34 (0.97–1.86)
High DAI ($n = 245$)	0.44 (0.27–0.71)	0.84 (0.60–1.18)	1.00	0.93 (0.57–1.51)
Low DAI ($n = 2078$)				1.00 (Ref.)
Medium DAI ($n = 581$)	0.64 (0.45–0.92)	0.83 (0.61–1.13)	0.75 (0.54–1.03)	1.00
High DAI ($n = 245$)	0.47 (0.26–0.86)	0.90 (0.56–1.45)	1.08 (0.66–1.75)	1.00

[a] Multivariable models were adjusted for age, sex (female and male), race/ethnicity (non-Hispanic White, non-Hispanic Black, and Hispanic or other), education (less than high school, high school graduation, training after high school, and college or post-grad, and unknown), area deprivation index (quartiles and unknown), smoking (never, former, current, and unknown), multivitamin use (yes and no), single supplement use (yes and no), cancer treatments—platinum-based chemotherapy, other chemotherapy, chest radiation, cranial radiation, other radiation (yes and no)

to each other, no one diet was better or worse than the other: Compared to the fast-food diet, neither Western contemporary (multivariable $OR_{\text{high vs. low DAI}} = 1.17$, 95% CI: 0.83–1.65) nor the animal-based diet (multivariable $OR_{\text{high vs. low DAI}} = 1.16$, 95% CI: 0.72–1.86) was statistically significantly associated with DAI. Similarly, the odds of being in the high DAI group for survivors with the animal-based diet were the same as those with the Western contemporary diet (multivariable $OR_{\text{high vs. low DAI}}$ for animal-based vs. Western contemporary diet = 0.99, 95% CI: 0.61–1.62).

The increased odds of being in the high vs. low DAI group for survivors with the fast-food, Western contemporary, and animal-based diet compared to those with the plant-based diet were consistent, albeit statistically non-significant, observed in subgroups of age (< 30/ ≥ 30 years), sex (male/female), race/ethnicity (non-Hispanic Whites/others), area deprivation index (low/high), smoking (never/ever), age at cancer diagnosis (< 10 and ≥ 10 years), cancer type (leukemia, lymphoma, others), radiation therapies (yes/no), and chemotherapy (platinum-based/others, Fig. 1A–C). A lower odds of being in the high vs. low DAI group for survivors with the plant-based diet compared to those with the fast-food diet and other dietary patterns (Additional file 1: Fig. S1) were also consistently observed across subgroups.

Discussion

This study identified that childhood cancer survivors who consume a predominantly plant-based diet are at lower risk of premature aging, as assessed by the DAI. Unfortunately, only an alarming one in five survivors does so. Conversely, greater than two thirds of survivors consume a Western contemporary diet or a fast-food diet, which are related to an increased risk of premature aging. This study is the first study to examine dietary patterns specific to childhood cancer survivors and their associations with premature aging, identifying a critical target for educational and behavioral intervention in this vulnerable population.

(See figure on next page.)

Fig. 1 Multivariable-adjusted[a] odds ratios and 95% confidence intervals of high deficit accumulation index (DAI) vs. low DAI[b] compared to plant-based diet in subgroups of adult survivors of childhood cancer: St. Jude Lifetime Cohort Study ($n = 2904$). a. Multivariable models were adjusted for followings except for the stratification variable: age, sex (female and male), race/ethnicity (non-Hispanic White, non-Hispanic Black, and Hispanic or other), education (less than high school, high school graduation, training after high school, and college or post-grad, and unknown), area deprivation index (quartiles and unknown), smoking (never, former, current, and unknown), multivitamin use (yes and no), single supplement use (yes and no), cancer treatments—platinum-based chemotherapy, other chemotherapy, chest radiation, cranial radiation, other radiation (yes and no). b. Deficit accumulation index (DAI) was assessed based on 44 aging-related health conditions and grouped into low (< 0.2), medium (0.2– < 0.35), and high (≥ 0.35) deficit accumulation categories. c. Area deprivation index: low was defined as below median and high was above median. d. Squares and lines represent odds ratios and 95% CIs, and arrows indicate the 95% CIs exceed the specified x axis limits

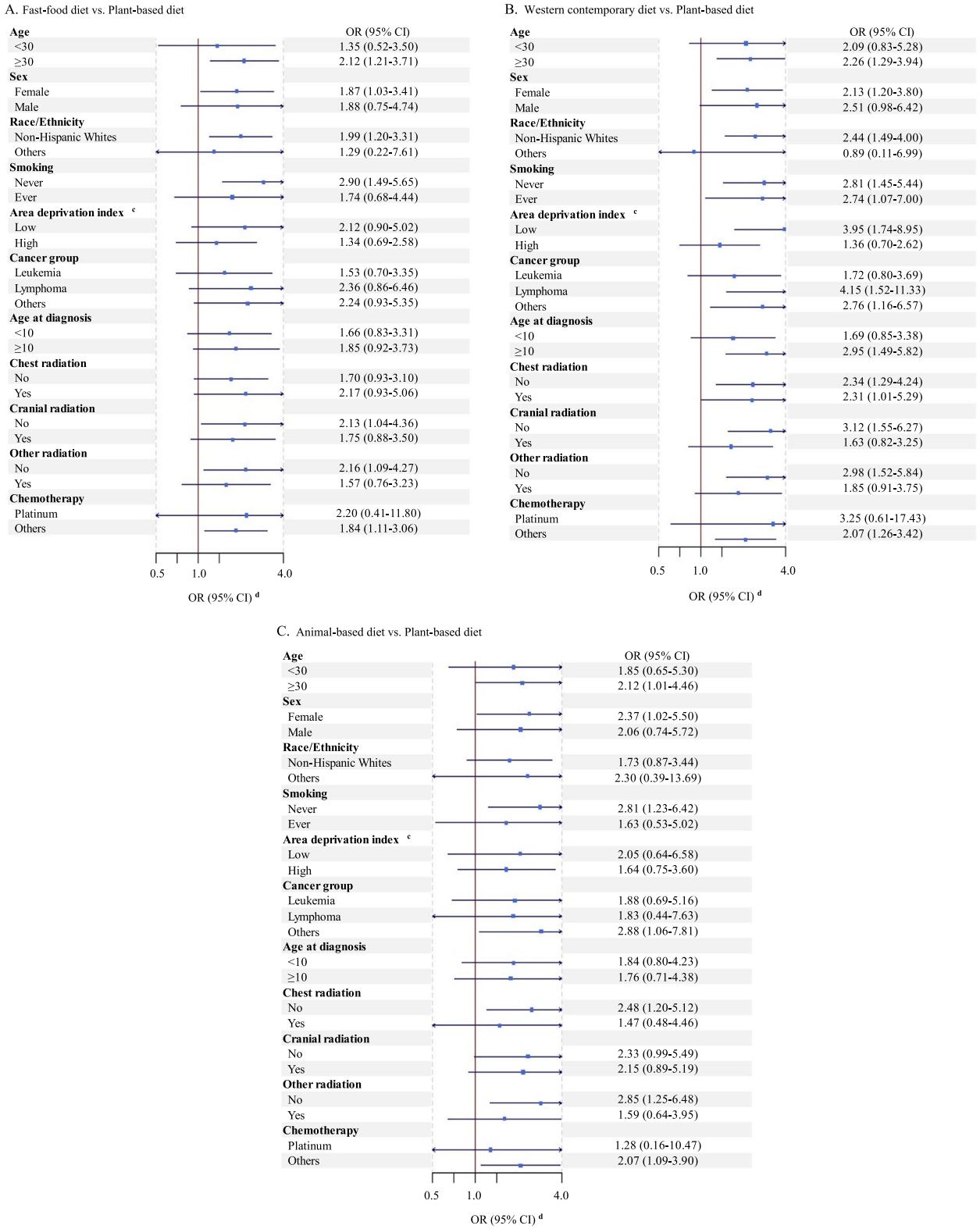

Fig. 1 (See legend on previous page.)

The beneficial effects of a plant-based diet and the detrimental effects of fast-food and Western contemporary diets on premature aging that we observed are consistent with previous studies conducted in the general population and survivors of adult cancer [7, 8, 18–21]. Plant-based diets, such as the Dietary Approaches to Stop Hypertension (DASH), the Mediterranean diet, and a prudent diet, have been associated with longer telomeres and slower epigenetic aging [7, 8, 20, 21]. In addition, these plant-based dietary patterns have been associated with a lower risk of aging-related chronic diseases, such as cardiovascular disease, diabetes, cognitive function decline, frailty, and overall mortality [22–26]. On the other hand, diets characterized by a higher intake of meat, high-fat dairy, refined grains, sweets, salty snacks, and sugar-sweetened beverages have been associated with an increased risk of these aging-related diseases [18, 27–29].

In our previous study of individual foods in SJLIFE, we found that dark green vegetables, nuts and seeds, and nutrients abundant in plant foods (e.g., folate, carotenoids, vitamin E) were associated with a lower risk of premature aging [10]. These particular foods and nutrients, along with other plant-based foods within a plant-based diet pattern, are known to be involved in various aging-related biological mechanisms, such as oxidative stress, inflammation, insulin resistance, gut dysbiosis, and epigenetic changes [30–32]. Also, meat, animal fat, and sugar which are abundant in a fast-food or a Western contemporary diet induce inflammation and oxidative stress, alter the composition of gut microbiota, and accelerate the aging process [33]. When individual foods are consumed collectively, the overall pattern of food consumption (i.e., dietary pattern) affects nutrient absorption, metabolism, and physiological responses in the body, exerting additive and synergistic effects in preventing or accelerating premature aging. Dietary recommendations focusing on dietary patterns instead of single foods or nutrients will ensure survivors consume various foods from different food groups, promoting overall balance in nutrient intake. Moreover, it allows for flexibility and personalization, making it more practical for survivors to achieve and maintain long-term dietary changes.

Although it was the least common diet, 14% of survivors had an animal-based diet that consumed a greater amount of all types of meats, including red meat, poultry, and fish. As a result, this diet led to a higher protein intake than other dietary patterns. In previous studies, higher total protein intake was associated with a lower premature aging risk, in particular, physical frailty, overall frailty, and cognitive decline in older adults [34–36]. Considering protein is a key nutrient to preserve muscle mass and muscle strength but not stored in the body for later use, sufficient consumption of protein may prevent physical frailty in vulnerable populations like older adults and childhood cancer survivors. However, higher animal protein intake was associated with an increased risk of insulin resistance, diabetes, kidney disease, and cardiovascular disease mortality [37–40]. Moreover, a diet high in animal foods tends to have high intake of animal fat, which is related to an increased risk of aging-related chronic diseases [41, 42]. In our study, we found that compared to those with a plant-based diet, survivors with the animal-based diet had a twofold increased odds of being in the high DAI group, suggesting the animal-based diet, as a whole diet, is not an optimal eating pattern for healthy aging.

We observed variability in the prevalence of dietary patterns by cancer types but not by cancer treatment history. For example, lymphoma survivors tended to have a higher prevalence of a plant-based diet than other survivors, whereas survivors of central nervous system were more likely to consume an animal-based diet. Similarly, the Swiss Childhood Cancer Survivor Study (age 20–50 years old) reported that survivors of lymphoma had the highest diet quality score (Healthy Eating Index score = 51.2 out of 110), while those of central nervous system had the poorest diet quality score (Healthy Eating Index score = 47.2) [43]. However, regardless cancer types, we consistently found a positive effect of a plant-based diet and detrimental effects of fast-food, Western contemporary, and animal-based diets on premature aging risk in all types of cancer survivors. These were also consistently observed regardless of types of cancer treatment, suggesting that diet plays a role in aging process in all childhood cancer survivors.

There are several limitations in our study. Due to the study's cross-sectional nature, the temporal relationship between diet patterns and premature aging could not be established. Future longitudinal studies, prospectively examining the effects of diet patterns on aging, are needed. Another limitation inherent to the study design is self-reported diet that is likely to have some miss-reporting. To reduce the impact of miss-reporting, we excluded survivors with incomplete diet data or extreme energy intake and adjusted for total energy intake in analyses. Additionally, a lack of racial/ethnic diversity in study participants limited our ability to explore dietary patterns in each racial/ethnic group. Lastly, although we controlled for confounders, such as sociodemographic factors, area deprivation index, and health behaviors, we cannot rule out potential residual confounding. However, analyses stratified by these variables showed consistent results across all subgroups, suggesting no substantial residual confounding.

Notable strengths of our study include a large number of long-term survivors of childhood cancer with a wide range of ages, diverse sociodemographic characteristics, and various cancer types and treatment histories, resulting in identification of four distinctive dietary patterns in this understudied population and making the results applicable to most of childhood cancer survivors. Also, the DAI, a proxy for premature aging, reflected 44 aging-related health conditions that were identified through comprehensive clinical and physical examinations, medical records, and self-reported aging-related conditions. Moreover, the DAI was associated with mortality and epigenetic age acceleration assessed by DNA methylation [15, 44].

Conclusions

Our findings show that the majority of adult survivors of childhood cancer consume less healthy dietary patterns that were associated with an increased risk of premature aging. As childhood cancer survivors now have extended lifespan, it is critical for childhood cancer survivors and healthcare providers to prioritize healthspan and promote healthy aging beyond survival. Given that dietary choices can be modified, incorporating nutrition counseling, education, and interventions to the survivorship care for adult survivors of childhood cancer may support healthy aging in this vulnerable population.

Abbreviations

CI	Confidential interval
DAI	Deficit accumulation index
DASH	Dietary Approaches to Stop Hypertension
FFQ	Food frequency questionnaire
OR	Odds ratio
SJCRH	St. Jude Children's Research Hospital
SJLIFE	St. Jude Lifetime Cohort Study

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12916-025-03940-3.

Additional file 1: Table S1. Mean intakes of food and nutrients by dietary patterns in adult survivors of childhood cancer: St. Jude Lifetime Cohort Study. Method S1 Dietary pattern identification method. Table S2. St. Jude Lifetime Cohort aging-related deficit accumulation index. Table S3. Age-adjusted odds ratios and 95% confidence intervals of deficit accumulation indexcategories by dietary patterns in the St. Jude Lifetime Cohort Study. Fig. S1. Multivariable-adjusted[1] odds ratios and 95% confidence intervals of high deficit accumulation indexvs. low DAI for consuming plant-based diet compared to Western contemporary, animal-based, and fast-food diets in subgroups of adult survivors of childhood cancer: St. Jude Lifetime Cohort Study.

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Authors' contribution

Conceptualization: YP, MMH, LLR. Data curation: MW, JQL. Funding acquisition: MMH, GAC, LLR, YP. Formal Analysis: TL, MW. Investigation: TL, MW, AMW, MJE, JQL, SJ, KRK, GTA, MMH, GAC, LLR, KKN, YP. Project administration: GTA, MMH, LLR, YP. Supervision: MMH, GAC, LLR, YP. Writing—original draft: TL, YP. Writing—review & editing: MW, AMW, MJE, JQL, SJ, KRK, GTA, MMH, GAC, LLR, KKN. All authors read and approved the final manuscript.

Author's Twitter handles

Not applicable.

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Data availability

Data can be obtained on request. Requests should be directed to the St. Jude LIFE (https://sjlife.stjude.org/), which has a protocol for approving data requests.

Declarations

Ethics approval and consent to participate

The study was approved by the St. Jude Children's Research Hospital Institutional Review Board (#00000029 FWA00004775; IRB number: SJLIFE; reference number: 027446), and all participants provided written informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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