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# Dietary Intake Patterns Are Consistent Across Seasons in a Cohort of Healthy Adults in a Metropolitan Population

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**ABSTRACT**

**Background** Current literature provides conflicting data regarding seasonal variability in dietary intake.

**Objective** Our aim was to examine seasonal variation in dietary intake in healthy adults from the metropolitan Washington, DC, area.

**Design** This study utilized an observational cohort design.

**Participants/setting** Male and female healthy volunteers (n=103) between the ages of 18 and 75 years were recruited from the metropolitan Washington, DC, area to participate in a clinical study at the National Institutes of Health Clinical Center from February 2011 to June 2014.

**Main outcome measures** Three- to seven-day food records were collected from subjects (n=76) at three time points (12 to 15 weeks apart). Subjects were excluded from analysis (n=27) if they completed less than three time points. Food records were reviewed by nutrition staff, assigned to a season, and coded in Nutrient Data System for Research for energy, macronutrient, micronutrient, and food-group serving analysis.

**Statistical analyses** Multivariate general linear models were run on energy, macronutrient, micronutrient, and food-group intakes, while being adjusted for age, sex, race, and body mass index (calculated as kg/m$^2$).

**Results** Subjects had a mean±standard deviation body mass index of 25±3.9 and age of 34±12.4 years. Subject demographics were 71.1% white, 9.2% black/African American, 13.2% Asian, and 6.6% unknown race, with 44.7% males and 55.3% females. Mean intake of energy across seasons was 2,214.6±623.4 kcal with 17.3%±4.1%, 33.6%±5.5%, 46.6%±8.0%, and 2.7%±3.2% of calories from protein, fat, carbohydrate, and alcohol, respectively. Intakes of energy, macronutrients, micronutrients, and food groups did not differ between seasons.

**Conclusions** People living in the metropolitan Washington, DC, area did not exhibit seasonal variation in dietary intake. Therefore, when designing studies of nutrient intake in a metropolitan population, these findings suggest that investigators do not need to consider the season during which diet is examined.

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A VARIETY OF METHODS ARE USED TO ASSESS HUman dietary intake, including 24-hour recalls, food records, food frequency questionnaires (FFQs), and biomarkers.[1] Previous studies cite intra-individual variation as the main barrier in obtaining representative dietary intake data from each of these collection methods.[1] Factors that influence within-subject variation include day to day, weekday to weekend and, relevant to this study, season to season variation.[1] The possibility of seasonal variation in dietary intake raises concerns regarding the accuracy of intake data in studies spanning multiple seasons. Similarly, if seasonality exists in dietary intake, researchers would incorporate seasonal bias when generalizing their results across all seasons if data were collected only in a single season. In many regions of the world, it is well-established that dietary patterns change with the seasons related to cyclical availability of food.[2] However, there are limited data examining the seasonality of dietary intake in developed countries, where it is believed that there is a more limited effect of season on access to food.

Current literature is inconsistent regarding seasonal variation of energy, macronutrient, and micronutrient intakes in industrialized regions. For example, in adults living in the

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United States, increases in overall energy intake were seen in the fall,[3] while in a sample of young, Spanish adults, greatest energy intake occurred in the winter.[4] Many investigators have reported seasonal changes in macronutrient intakes, even after adjusting for any seasonal changes in total energy intake.[2,4-6] Seasonal differences in fat and protein intake have been described,[2,4-9] but seasonality of carbohydrate intake is most consistent across studies, with several researchers showing highest intakes in the summer.[2,4,6,8] In addition, while a lack of seasonal differences in vitamin[6,8] and mineral[6-8,10-16] intakes has been shown, some reports have noted equivocal seasonal changes in select micronutrients. For instance, a few studies identified summer as the season with the highest intake of vitamin C, vitamin A, vitamin D, thiamin, and vitamin B-6,[4,5,7,11] but contrastingly, others have demonstrated lowest intakes of vitamin C and vitamin A in summer.[4,10,17] In addition, sodium, zinc, and magnesium intakes have been noted to increase in the winter compared with the summer[9]; however, others have reported that intake of these minerals was highest in the spring.[17] These inconsistencies in the data can be attributed to different methodologies, including use of FFQs, food records of various lengths, and 24-hour diet recalls, as well as to dissimilar samples of participants.

Researchers have also focused on seasonal differences in the consumption of various food groups. Three studies found increases in vegetable consumption among women in the summer months compared with winter.[2,4,7] Reports regarding seasonal changes in protein-based food groups, such as eggs, meat, seafood, and legumes, have been inconsistent; some have stated a lack of seasonality,[2,7,18] while others have shown increases in protein-based foods in the winter months compared with summer months.[4,6,9,19] From the studies reviewed, there were no significant differences in grain,[2,4,6,7] oils or fats,[2,4,7] or sugar-based foods or sweets.[2,4,7,18] Findings regarding seasonality of fruit, beverage, and dairy intake were demonstrated in single studies and were not considered to be trends of seasonal intake.[2,18]

Of the studies mentioned, those that took place in the United States limited their analysis to select nutrients or food groups.[3,12,13,20,21] To our knowledge, a broad analysis of seasonality in dietary patterns has not yet been conducted in a metropolitan area of the United States. The objective of this observational cohort study was to examine whether seasonal variation in dietary intake exists in a sample of healthy, adult men and women from the metropolitan Washington, DC, area. A review of the literature does not indicate common patterns in seasonal variation in dietary intake, and multiple analyses demonstrate a lack of seasonal variation altogether. Therefore, we hypothesize that there will be a lack of seasonal variation in dietary intake as assessed by food records in a population of healthy adults from the metropolitan Washington, DC, area.

## METHODS

### Subjects

Subjects were enrolled in a clinical pilot study carried out at the National Institutes of Health (NIH) Clinical Center in Bethesda, MD (clinicaltrials.gov identifier NCT01131299) from February 2011 to June 2014. The trial was approved by the NIH National Heart, Lung, and Blood Institute's Institutional Review Board; informed consent was obtained from all subjects before study initiation; and procedures were carried out in accordance with Institutional Review Board regulations. Male and female (n=103) volunteers between the ages of 18 and 75 years were recruited through the NIH Clinical Center Patient Recruitment Office from the metropolitan Washington, DC, area. Subjects were excluded from enrolling in this protocol if they were pregnant or breastfeeding, had a body mass index (BMI; calculated as kg/m$^2$) <18.5, had an unstable weight that varied >10% during the previous 3 months, were following a low-fat diet (<20% of total energy intake), or routinely consumed fewer than three meals/snacks per day. Protocol exclusion criteria also included use of unstable doses of medications known to affect fat absorption, anticoagulants, anticonvulsants, antidysrhythmics, cyclosporine, mycophenolate, or thyroid hormone supplementation; vitamin A, D, E, and/or K deficiencies; type 1 or 2 diabetes; or gastrointestinal conditions that could affect intestinal fat absorption.

### Dietary Assessment

Dietary intake was assessed at baseline and at two additional visits with 12 to 15 weeks between each visit; each subject recorded their intake in three different seasons. Subjects were instructed not to change their typical diet or physical activity during the study period. Three-day to seven-day food records, with an average length of 6.0±1.5 days (mean± standard deviation), including a minimum of 2 weekdays and 1 weekend day, were kept by the subjects during the week before each visit. Food records were collected and reviewed for additional detail by nutrition department staff. To reflect the marketplace throughout the study, dietary intake data were coded using Nutrition Data System for Research software (versions 2009 through 2013, Nutrition Coordinating Center, University of Minnesota). Food groups included fruits (all fruit including citrus), citrus fruits, vegetables (excluding legumes), grains, dairy, protein (including legumes and seafood), seafood, discretionary (fats, oils, sugar, condiments), nonalcoholic beverages (excluding 100% fruit juice, dairy, and water), and alcoholic beverages. Food-group servings are based on the recommendations made by the 2000 Dietary Guidelines for Americans[22] or on Food and Drug Administration serving sizes[23] for foods not included in the guidelines. Season assignment was based on the season during which most days of recorded intake occurred, with seasons defined as winter (December 21 to March 20, n=54), spring (March 21 to June 20, n=60), summer (June 21 to September 20, n= 60), and fall (September 21 to December 20, n=54). All 228 food records were analyzed for macronutrient and mineral intake. Vitamin analysis removed one set of food records for unusually high vitamin B-12 intake secondary to clam consumption and one set of food records for unusually high retinol intake secondary to liver consumption (n=226). One set of food records was removed before food-group analysis because fruit intake was zero and the data could not be log transformed (n=227).

### Statistical Analysis

Of the 103 subjects who were enrolled in the study, 76 were included in the statistical analysis. Subjects were excluded if they completed fewer than three visits. Analyses were