ORIGINAL ARTICLE

Mineral and vitamin consumption and telomere length among adults in the United States

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KEY WORDS

dietary pattern, factor analysis, telomere length

ABSTRACT

INTRODUCTION Shorter leukocyte telomere length (TL) is associated with several chronic diseases, but only a few studies have assessed the associations of dietary components and dietary patterns with TL in adults in the United States (US).

OBJECTIVES This study was aimed to determine the relation of dietary components and dietary patterns with TL among adults in the US.

PATIENTS AND METHODS National Health and Nutrition Examination Survey (NHANES) participants with data on dietary intake and TL measures from 1999 to 2001 were included. Daily intakes of 60 nutrients and bioactive compounds were calculated for each participant. Factor analysis, followed by a varimax rotation, was applied to derive the major nutrient patterns. All statistical analyses accounted for the survey design and sample weights.

RESULTS Of the 10 568 eligible participants, 48.0% (n = 5020) were men; the mean age was 44.1 years. Mean (adjusted for sex, age, and race) dietary intakes of carbohydrate, dietary fiber, total folate, vitamin B_6, magnesium, iron, copper, polyunsaturated fatty acids 22:5, and vitamin C monotonically increased across TL quarters ($P < 0.05$ for all), while total fat and caffeine decreased across TL quarters ($P < 0.05$ for all). Three food patterns together explaining 56.8% of the variance of the dietary nutrient consumption were identified. We found that the second food pattern, which was a representative of minerals and vitamins, monotonically increased across TL quarters and had a positive association with TL.

CONCLUSIONS Higher mineral and vitamin consumption is associated with longer telomeres among adults in the US.

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INTRODUCTION Telomeres are important and active controllers of cellular lifespan and chromosome integrity in eukaryotes cells, made up of guanine-rich sequence TTAGGG.[1] Telomeres shorten at each cycle of cell division because DNA polymerases are not capable of completely replicating linear chromosomes, which is also recognized as the end-replication problem.[2] Therefore, shortened telomere is viewed as a surrogate of aging. Available evidence suggests that short leukocyte telomere length (TL) is linked with increased risk for various chronic conditions including cardiovascular disease,[3] hypertension,[4] type 2 diabetes,[5] metabolic syndrome,[6,7] higher body mass index,[8] insulin resistance, and some types of cancers.[5,9]

Available studies have reported that energy intake and diet composition affect TL.[1,10] Restricted calorie intake reduces the production of reactive oxygen species and prevents TL shortening.[1,11] It has also been reported that antioxidant-rich diets including a high intake of vegetables and fruits, may influence the aging process favorably and decrease the pace of telomere attrition.[4,12] In this regard, Mediterranean diet, mostly containing

vegetables, legumes, fruits, grains, fish, single unsaturated fatty acids, and dairy products, had a protecting impact on TL.[13] On the other hand, diets containing high amounts of saturated fatty acids (SFAs) may accelerate telomere shortening in comparison with the Mediterranean diet rich in monounsaturated fatty acids (MUFAs).[14]

To date only a few investigations have studied the relations between dietary factors and TL, but the results have been largely inconsistent.[15-17] In addition, the association between the exact proportions of dietary components and TL has not been explored yet.[1] In this study, we have investigated the association between dietary components and dietary patterns with leukocyte TL, using data for adults in the United States (US) who took part in the Nutrition and Health Examination Surveys (NHANES).

PATIENTS AND METHODS **Population** The NHANES are ongoing repeated cross-sectional surveys conducted by the US National Center for Health Statistics. Data collection on demographic, dietary, and behavioral information occurs through in-home administered questionnaires, while anthropometric and biomarker data are collected by trained health workers, using mobile exam units.[18,19] More detailed information on the NHANES, particularly on dietary recall and TL measurements, is available elsewhere.[19,20] We identified participants aged 18 years or older for the downstream analyses.

Statistical analysis We conducted the analyses according to the guidelines set forth by the Centers for Disease Control for analysis of complex NHANES dataset, accounting for the masked variance and using the proposed weighting methodology.[18] Factor analysis with orthogonal transformation (varimax procedure) was applied to derive nutrient patterns based on the nutrients and bioactive compounds. Factors were retained for further analysis based on their natural interpretation and eigenvalues on the Scree test.[21,22] We computed the factor score for each nutrient pattern by summing up intakes of nutrients weighted by their factor loadings.[21,22] Each participant received a factor score for each identified pattern, accounting for the fact that simple linear dose--response relationships are unlikely to be found in nutritional epidemiology.[23] We computed age-, sex-, and energy-adjusted intakes of food groups and nutrients using analysis of covariance. To determine any association between nutrient patterns and TL, we used multivariable logistic regression. Categorical demographic variables were compared by using χ^2 tests. All tests were 2-sided, and a P value of less than 0.05 denoted the level of significance. Data were analyzed using SPSS complex sample module version 22.0 (IBM Corp, Armonk, New York, United States).

RESULTS Of the 10 568 eligible participants, 48.0% (n = 5020) were men. The mean age was 44.1 years overall, and 43.5 years in men and 44.8 in women (P = 0.065). With regard to education, 52.5% (n = 4022) of the participants had completed more than high school, 25.6% (n = 3248) had completed high school, while 21.7% (n = 2178) had completed less than high school. White people (non-Hispanic) represented 70.4% (n = 4864) of the participants and Mexican-American minorities represented 6.9% (n = 2103). The mean TL was 1.03 (range, 0.84–1.17) overall, 1.01 (range, 0.86–1.19) in men, and 1.05 (range, 0.86–1.19) in women (P = 0.125).

Using a principal components analysis method, we reduced the dietary variables from 63 variables to 3 total principle components (PCs) that altogether explained 56.8% of the variance of the dietary nutrient consumption. *Table S1* (Supplementary material online) illustrates the nutrients that contributed to each PC. Accordingly, the first PC was mainly representative of saturated and monounsaturated fatty acids, the second PC represented vitamins and minerals, and the third PC was mainly representative of polyunsaturated fatty acids (PUFAs). *Table S1* shows the age-, sex-, and race-adjusted mean of each nutrient by quarters of the 3 PCs. As expected, for the nutrients that were constituent elements of a PC, there was a highly significant increase in trends of the nutrient intake across the quarters of the corresponding PC (P <0.001). For the nutrients that are not constituent elements of the other PCs, the trends are either weak or reversed.

The association of nutrients intake with TL is summarized in Supplementary material online, *Table S2*. Mean (adjusted for sex, age, and race) dietary intakes of carbohydrate, dietary fiber, total folate, vitamin B_6, magnesium, iron, copper, PUFA 22:5, and vitamin C monotonically increased across TL quarters (P <0.05 for all comparisons), while dietary total fat and caffeine decreased across TL quarters (P <0.05 for all comparisons). The second food pattern, which was a representative of minerals and vitamins, monotonically increased across the quarters of TL (P = 0.042) (**TABLE 1**). In stepwise linear regressions (Supplementary material online, *Table S3*), vitamin E, MUFA 16:1, MUFA 20:1, and caffeine were negatively related to the TL (P <0.05), while total folate was positively related to TL (P <0.05). In multivariate-adjusted (age, race, and sex) linear regressions, the second food pattern, which mostly comprised vitamins and minerals, was positively associated with TL (P <0.05).

DISCUSSION We found that adjusted mean dietary total fat and caffeine decreased across increasing TL quarters, and vitamin E, MUFA 16:1, MUFA 20:1, and caffeine were negatively related to the TL. Moreover, the second food pattern monotonically increased across the quarters of TL and had a positive association with TL.

An American cross-sectional study[24] reported an inverse association between food groups and

TABLE 1 Age-, sex-, and race-adjusted mean of score of food patterns across the quarters of telomere length

Variables	Quarters of telomere length			
	Q1 (n = 1923)	Q2 (n = 2043)	Q3 (n = 1877)	Q4 (n = 1984)
telomere length	0.74 (0.04)	0.92 (0.01)	1.08 (0.02)	1.39 (0.01)
first pattern (fatty acids)	296.5 (6.08)	314.4 (6.60)	302.8 (5.94)	296.8 (5.71)
second pattern (minerals and vitamins)	5877.2 (100.0)	6087.2 (87.8)	6111.8 (86.8)	6232.0 (91.9)
third pattern (polyunsaturated fatty acid)	12.43 (0.24)	13.26 (0.32)	12.63 (0.32)	12.79 (0.30)

Data are presented as mean (standard error of the mean).

Abbreviations: Q, quarters; SE, standard error; TL, telomere length

2 different dietary patterns (fats and processed meat, whole grains and fruit). Inflammation and oxidative stress have been proposed as a possible explanation for the observed association between fat intake and the shortening of TL.[25-27] Chan et al[28] reported an inverse association between TL and the intake of fats and oils in elderly Chinese women. The oils used were reported to be mainly maize and peanut oils, which are rich in MUFAs and PUFAs. We also found an inverse association between MUFAs and TL.

The increasing dietary intakes of PUFA 22:5 across TL quarters in our study are at variance with findings from other published studies. A large cross-sectional study comprising control subjects of the Nurses' Health Study found a high PUFA intake, and especially a high intake of linoleic acid, to be inversely associated with TL.[16] The same study, however, found no association between n-3 fatty acids, total fatty acids, and SFAs or MUFAs and TL.[16] We found the food pattern comprising minerals and vitamins to be positively associated with TL in adjusted models. Moreover, intakes of dietary fiber, total folate, vitamin B_6, magnesium, iron, copper, and vitamin C also increased across the quartiles of TL. Our results are in line with recent findings by Marcon et al[17] that a high intake of vegetables is positively associated with TL. Moreover, in a very recent meta-analysis, Rafie et al[29] reported the positive association of fruits or vegetables with TL. Antioxidants, found in abundance in vegetables and fruits, seem to protect telomeres from attrition.[30,31] However, several studies reported opposite findings. In a case-control study conducted in Poland, which involved cancer patients aged 62 years or older and healthy controls, TL decreased with decreasing fruit intake in both groups, but not with vegetable intake.[9] An association between fruit and vegetable intake and TL was not found either in a large cross-sectional study assessing fruit and vegetable intakes combined[15] or in studies assessing fruit and vegetable intakes separately.[24,28] A large Belgian cross-sectional study also found no association between TL and fruit and vegetable intake (combined), but when a low fruit and vegetable intake was assessed as part of an unhealthy lifestyle score, a positive association was found.[15] Rafie et al[29] supported the health benefits of adherence to Mediterranean diet for TL; furthermore, it has been indicated that specific food groups including processed meat, cereals, and sugar-sweetened beverages may be related with shorter TLs.[29]

Available studies have also reported inconsistent associations between coffee consumption and TL.[5,32] In an intervention study comprising 40 patients with chronic hepatitis C, TL was found to be significantly longer in patients during the experimental period of consuming 4 cups of coffee per day for 30 days.[32] A cross-sectional study found no significant association between coffee consumption and TL in 840 white, black, and Hispanic participants of the Multi-Ethnic Study of Atherosclerosis[24]; however, the focus of the study was not specifically on coffee but on dietary patterns and food groups. On the other hand, the Nurses' Health Study[16] found an inverse relationship between caffeine and TL in women.

Some explanations have been proposed for contradictory findings of different studies regarding the effects of dietary pattern on TL. TL is controlled by genetic and inherent variances and the handful of available studies has been conducted in different countries with divergent ethnicities, which might have restricted the capability to detect relations between TL and dietary components.[29,33] The divergent findings may have also resulted from differences in cooking procedures and amounts of foods used.[4,29]

Our study was based on a nationally representative survey, which is a major strength. Limitations include the cross-sectional design of the NHANES, precluding inferences about causation.

In conclusion, we found that higher consumption of minerals and vitamins was associated with longer telomeres.

Supplementary material online Supplementary material is available with the online version of the article at www.pamw.pl.

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Contribution statement MM contributed to the study concept and design, data analysis and interpretation, and drafting of the manuscript. APK contributed to critical revision of the manuscript for important intellectual content. MB contributed to critical revision of the manuscript for important intellectual content.

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