Television Watching and Telomere Length Among Adults in Southwest China

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Objectives. To explore the independent associations of sedentary behavior and physical activity with telomere length among Chinese adults.

Methods. Data on total time of sedentary behavior, screen-based sedentary behavior (including television watching and computer or phone use), moderate to vigorous physical activity, and dietary intake of 518 adults in Chengdu, Guizhou, and Xiamen in China (54.25% women) aged 20 to 70 years were obtained between 2013 and 2015 through questionnaires. Height, weight, and waist circumference were measured to calculate body mass index and percentage of body fat. Telomere length was measured through Southern blot technique.

Results. Television watching was inversely related to adjusted telomere length (–71.75 base pair; SE = 34.40; *P* = .04). Furthermore, a similar trend between telomere length and television watching was found in the group aged 20 to 40 years after adjusting for all covariates. Adults aged 20 to 40 years in the highest tertile of daily time spent on watching television had 4.0% shorter telomere length than adults in the lowest tertile (*P* = .03).

Conclusions. Although the association is modest, television watching is inversely related to telomere length among Chinese adults, warranting further investigation in large prospective studies. (*Am J Public Health.* 2017;107:1425–1432. doi:10.2105/AJPH.2017.303879)

See also Du, p. 1360.

Telomere length shortening, a potential indicator of cellular aging,[1] predicts various age-related diseases, such as type 2 diabetes,[2] cardiovascular disease,[3] and cancer, as well as mortality.[4] Although the specific mechanisms of telomere length shortening are complex, oxidative stress and inflammation balances in the cellular environment are key determinants of the rate of telomere length shortening.[1] Sedentary behavior and physical activity are modifiable factors that contribute to these balances and may be implicated in these trends.

With almost 83% of Chinese adults spending 2 or more hours per day in sedentary pursuits and 82% of Chinese adults spending less than 150 minutes in moderate-intensity physical activity weekly (the World Health Organization's recommendation),[5] excess sedentary behavior and lack of physical activity are major health concerns in China, a country that tops the list of countries for number of adults with many age-related diseases.[6]

Few studies have examined the associations between sedentary behavior or physical activity and telomere length. To date, only 2 cross-sectional studies among US adults[7,8] have evaluated the relationship between sedentary behavior and telomere length, and they came to different conclusions. The National Health and Nutrition Examination Survey study revealed an inverted association,[7] independent of physical activity and body mass index (BMI), whereas the Nurses' Health Study reported no association.[8] Despite large sample sizes, these studies did not allow for the adjustment of total energy intake, an important potential factor contributing to the association between sedentary behavior and telomere length. Moreover, the potential role of specific types of sedentary behavior, such as television watching, on telomere length have not been examined. Observational studies[8–14] relating physical activity to telomere length have yielded inconsistent conclusions. Some studies found that greater engagement in physical activity is related to longer telomere length[8–10,13]; some studies reported no relationship between physical activity and telomere length[11]; and others revealed an inverted U–shaped relationship.[12,14] We are not aware of any studies examining the independent relationship of sedentary behavior and physical activity to telomere length among Chinese adults.

Given the limited research evaluating the associations between sedentary behavior, physical activity, and telomere length, a total of 637 adults (aged 20–70 years) from an ongoing, population-based prospective study in Southwest China were identified to examine whether the total sedentary behavior, screen-based sedentary behavior, specific types of screen-based sedentary behavior (television watching and computer and phone use) and moderate

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to vigorous physical activity (MVPA) are associated with telomere length as detected by the Southern blot technique, the most established method based on the absolute telomere length (mean terminal restriction fragments [TRF]).[15] Physical activity (in analysis of sedentary behavior), sedentary behavior (in analysis of physical activity), anthropometric indices, and energy intake were included as confounding factors.

METHODS

We used data from an ongoing, population-based prospective study conducted with adults from 21 communities (9 urban and 12 rural areas) of Chengdu, Guizhou, and Xiamen in China, beginning in September 2013, that aims to investigate the health impact of nutritional and lifestyle factors on the development of several chronic diseases or worsening of quality of life, as described elsewhere.[16] The participants were invited to the study center for interviews. Generally, each visit included anthropometric measurements, medical examinations, questionnaires, and face-to-face interviews by trained investigators about nutrition-related behaviors, lifestyles, and social status. All participants were followed biannually to obtain updated information. Participants who were cooperative, who volunteered, and who signed an informed consent form were included in this cohort study. However, the following participants were excluded: (1) those with cancer, (2) those with mental illness, (3) those taking hormone-based drugs and other medicines that affect blood glucose and lipids, and (4) those who were pregnant or lactating.

Data used in this study were identified from the baseline survey of the ongoing prospective study between 2013 and 2015. Participants in the present analysis have been shown to be comparable to age-matched adults in our cohort study and the general population of urban and rural areas in Southwest China on sociodemographic and lifestyle characteristics.[17] Initially, 637 adults aged 20 to 70 years were identified. Of these, 119 were excluded: 3 had missing sedentary behavior and activity information, 43 had incomplete anthropometric data, and 73 had incomplete information on potential confounders. Therefore, the present analysis is grounded in a final sample of 518 adults.

Telomere Length

A peripheral blood leukocyte specimen was collected from participants after an overnight fast (from midnight). Genomic DNA was extracted from isolated leukocytes with standard procedures using an AxyPrep Blood Genomic DNA Miniprep kit (Axygen, Corning, Inc., Corning, NY). The mean length of TRF, an absolute telomere length, was measured using the Southern blot–based in-gel hybridization technique,[18] in which a ^{32}P-labeled telomeric probe was used for hybridization, and the weighted mean telomere length was calculated as described previously.[19] The laboratory and person conducting the TRF length measurements were blind to all characteristics of the leukocyte donors. Quality control samples were interspersed on each gel to assess variability. With random sampling, the coefficient of variation for 3 independent measurements of the same sample displayed a very small coefficient of variation (2.31%; Figure B, available as a supplement to the online version of this article at http://www.ajph.org), demonstrating the reliability of telomere length assayed by Southern blot–based TRF. Given that TRF is a time-consuming assay that provides reliable and highly repeatable results, a 1-time experiment is usually sufficient to provide accurate telomere length.

Anthropometric Measurements

Trained medical workers in each study center obtained anthropometric measurements according to standard procedures. Using an ultrasonic instrument (Weight and Height Instrument DHM-30; Dingheng Ltd., Zhengzhou Province, China), weight and height were measured to the nearest 0.1 kilogram and 0.1 centimeter, respectively. Waist circumference was measured at the midpoint between the lowest rib and the iliac crest to the nearest 0.1 centimeter using inelastic tapes. Weight, height, and waist circumference were each averaged on the basis of 2 measurements. Quality of all anthropometric assessments in our large cohort study is controlled annually.

For this analysis, BMI was calculated as weight divided by height squared. Overweight was defined according to World Health Organization standards.[20] Percentage of body fat (%BF) was calculated using the equations from Liu et al.[21]

Sedentary Behaviors and Physical Activity

Sedentary behavior and physical activity inside and outside the workplace were collected through a detailed questionnaire similar to a previously validated tool for Chinese adults,[22] with some additional modifications after a pilot study. Participants were asked about typical type and yearly, monthly, weekly, and daily frequency and duration of sedentary (seated) activities, including television watching, using a computer or phone while sitting, reading, playing cards or mahjong, driving a car, and lying down while awake. On the basis of these data, the mean daily time spent on each type of sedentary behavior was estimated in hours by multiplying frequency and duration and dividing by 1 year, month, week, or day. Total sedentary behavior time was calculated as the sum of time spent on sedentary activities, and screen-based sedentary behavior time was calculated as the sum of time spent watching television and using a computer or phone.

To collect information about usual type and duration of activities related to work, household chores, and leisure-time exercise inside and outside the workplace during the past year, the questionnaire was designed to include a checklist of 38 items, for example, transportation (walking and climbing stairs); sports, exercise, and recreational activities (track and field, ball games, dancing); and household activities (dusting, sweeping, room tidying). Data on yearly, monthly, weekly, and daily frequency and duration of the corresponding physical activity were obtained. Daily time spent in physical activity was estimated by multiplying frequency and duration and dividing by 1 year, month, week, or day. To quantify the intensity of physical activity (metabolic equivalent tasks), the value for a particular type of physical activity representing the ratio of working metabolic rate to a standard resting metabolic rate of 1.0 (4.184 kJ) · kg^{-1} · h^{-1} was used according to a 2011 update of a published compendium of physical activity by category.[23] By multiplying the weight in kilograms by the metabolic equivalent task value and duration of activity, we estimated energy expenditure specific to a person's weight.[23] MVPA was characterized as greater than or equal to 3 metabolic equivalent tasks. Energy expended on MVPA per day was calculated.

Energy Intake

Dietary data were collected in face-to-face interviews with a validated 24-hour dietary recall.[16] In the interview, participants were asked to recall all foods and beverages consumed and the corresponding timing for the preceding 24 hours. Dietary data were collected on 2 random days within a 10-day period. Trained dieticians obtained information on recipes and the types and brands of all food items reported. Dietary intake data from 24-hour dietary recalls were converted into energy and nutrient data with the continuously updated in-house nutrient database based on NCCW software (version 11.0; Qingdao University Medical College, Shandong Province, China), which reflects the China Food Composition.[24] In this analysis, energy intake for each participant was calculated in megajoules per day.

Additional Information

Participants were asked to complete a self-administered questionnaire that collected information about their family characteristics, educational and employment status, and so forth.

For the present analysis, we assessed factors potentially associated with physical activity or sedentary behavior and telomere length, which included gender, age (in years), smoking status (currently smoking, no longer smokes, and never smoked), perceived stress evaluated with the Chinese Perceived Stress Scale[25] (0 = no; other scores = yes), alcohol consumption (yes–no), and other sociodemographic data, including education level (< 6 years, 6–12 years, and > 12 years of schooling), occupation (self-employed, casual laborer, manual worker, and non–manual worker), monthly family income (< 1000 RMB, 1000–2900 RMB, 3000–5900 RMB, and ≥ 6000 RMB), and monthly personal income (< 1000 RMB, 1000–2900 RMB, 3000–5900 RMB, and ≥ 6000 RMB).

In addition, C-reaction protein (CRP) was also measured through a peripheral blood specimen taken from participants after an overnight fast (from midnight).

Statistical Analyses

SAS procedures (SAS version 9.3, SAS Institute, Cary, NC) were used for data analyses. All analyses were performed with significance set at $P < .05$, except for interaction tests, in which $P < .1$ was used as a cutoff for inclusion in multivariable analysis. Preliminary analyses indicated no interactions between the relation of sedentary behavior and physical activity to telomere length with gender (Ps = 0.6–0.9); therefore, the main results are presented with both genders combined, adjusted for gender.

We used multivariable linear generalized regression models to investigate the independent associations of total time of sedentary behavior, screen-based sedentary behavior, specific types of screen-based sedentary behavior (including watching television and using a computer or phone), and MVPA energy expenditure with telomere length. We defined time of total sedentary behavior, screen-based sedentary behavior, television watching, and computer or phone use, as well as MVPA energy expenditure, as the independent variables, and telomere length was the dependent variable in separate models. Because of the skewed distribution of telomere length, the natural logarithm of telomere length was calculated to improve normality.

In the basic models, we first carried out the correlational analyses between total sedentary behavior, screen-based sedentary behavior, specific types of screen-based sedentary behavior, MVPA energy expenditure, and telomere length. In a further step, we added potential covariates affecting these associations. These covariates were gender; age; education level (< 6 years, 6–12 years, and > 12 years of schooling); occupation (self-employed, casual laborer, manual worker, and non–manual worker); average family monthly income (< 1000 RMB, 1000–2900 RMB, 3000–5900 RMB, and ≥ 6000 RMB); personal monthly income (< 1000 RMB, 1000–2900 RMB, 3000–5900 RMB, and ≥ 6000 RMB); sleep duration (hours/day); smoking status (currently smoking, no longer smokes, and never smoked); perceived stress[25] (yes–no); BMI; %BF; energy intake; antioxidant vitamin intake; polyunsaturated fatty acids, fat, fiber, and alcohol consumption (yes–no); MVPA energy expenditure in analysis of each sedentary behavior; and total sedentary behavior in analysis of MVPA energy expenditure. We initially considered each variable separately; only variables that had their own independent significant effect in the basic models or that substantially modified the principal associations of time spent on sedentary behavior and MVPA energy expenditure with telomere length were included in the subsequent multivariable analyses. Given that CRP may be an intermediate variable for the association between sedentary behavior and telomere length, we did not include CRP in the model in the process of analysis.

In exploratory analyses, we assessed associations of sedentary behavior and MVPA energy expenditure with telomere length stratified by categories of age by using multivariable linear generalized regression models. To ensure the number of participants in each age group and the statistical power to examine these associations, we categorized age into 3 groups: 20 years to 40 years, 41 to 55 years, and 56 to 70 years.

RESULTS

General characteristics of the sample in this study stratified by gender are presented in Table 1. In the present analysis, 54.25% of adults were women and the median age of participants was 47.57 years. The median of telomere length was 6356.02 base pairs (bp; range = 4250.03–10 283.78 bp). No significant difference was found for gender across all age groups (20–40, 41–55, 56–70

TABLE 1—Study Sample by Age Group: Chengdu, Guizhou, and Xiamen, China; September 2013–2015

	Age, Years, No. (%) or Median (IQR)			
Characteristics	20–40	41–55	56–70	P
No. (%)	174 (33.59)	187 (36.10)	157 (30.31)	
Age, y	32.80 (26.40, 37.20)	48.30 (44.93, 51.10)	60.70 (58.40, 64.11)	
Female	99 (56.89)	90 (48.13)	92 (58.60)	.1
Leokocyte telomere length, base pairs	6817.92 (6234.33, 7250.66)	6268.15 (5807.70, 6867.23)	6070.04 (5668.07, 6650.08)	≤ .001
Sedentary behavior, hr/d				
Television watching	1.00 (0.00, 2.29)	2.00 (1.00, 3.00)	2.00 (1.00, 3.00)	≤ .001
Computer/phone use	4.62 (2.57, 7.50)	1.00 (0.20, 3.50)	0.30 (0.10, 1.33)	≤ .001
Screen-based sedentary behavior[a]	6.50 (4.00, 9.00)	4.00 (2.10, 6.00)	2.70 (1.70, 4.50)	≤ .001
Total sedentary behavior	7.12 (5.14, 10.05)	4.00 (2.17, 6.29)	2.80 (1.80, 4.60)	≤ .001
C-reaction protein, mg/L	1.85 (1.10, 4.90)	4.30 (2.00, 5.30)	3.60 (2.00, 5.40)	≤ .001
MVPA energy expenditure,[b] MJ/d	2.38 (1.27, 3.67)	2.67 (1.53, 5.02)	3.12 (2.07, 5.09)	.001
Total energy intake, MJ/d	6.52 (4.98, 7.86)	6.32 (5.09, 7.92)	6.18 (5.09, 7.92)	.3
Anthropometric data				
Overweight,[c] %	43 (24.71)	85 (45.45)	65 (41.40)	.001
Body mass index, kg/m^2	21.87 (20.06, 24.97)	24.48 (22.23, 26.22)	24.59 (22.72, 26.42)	≤ .001
% body fat[d]	27.64 (23.99, 32.42)	32.69 (26.71, 38.22)	37.09 (28.31, 40.95)	≤ .001
Sociodemographic data				
High personal income per month[e]	93 (44.45)	69 (36.9)	29 (17.47)	≤ .001
High education level[f]	121 (69.54)	48 (25.67)	20 (12.82)	≤ .001
Smoking, current	31 (17.82)	40 (21.39)	28 (17.83)	.4
Stress in life,[g] yes	113 (64.94)	74 (39.57)	35 (22.29)	≤ .001

Note. IQR = interquartile range; MVPA = moderate to vigorous physical activity. Significant difference between age groups was tested using the Kruskal–Wallis test for non-normally distributed continuous variables and the χ^2 test for categorical variables. The sample size was n = 518.

[a]Screen-based sedentary behavior were the sum of time spent on television watching and computer/phone use.

[b]MVPA energy expenditure, energy expended on moderate-to-vigorous physical activities (MJ/d).[23]

[c]Body mass index ≥ 25 kg/m^2.[20]

[d]Calculated according to the equations developed by Liu et al.[21]

[e]Personal income per month ≥ 3000 RMB, which is moderate level among the general population in Southwest China.[17]

[f]At least 12 years of school education.

[g]Evaluated by 10-item Chinese perceived stress scale.[25]

years; P = .1). Participants in the older age groups had lower personal monthly income, lower education level, and less perceived stress; they engaged in more television watching, less computer or phone use, and more MVPA; they had shorter telomere length, higher BMI and %BF, and higher CRP; and they were more likely to be overweight (all Ps ≤ .001).

Sociodemographic and anthropometric characteristics of participants by tertiles of daily time spent watching television are given in Table 2. As expected, participants whose daily television watching time was in the highest tertile had lower education level, were more likely to smoke, and had shorter telomere length, higher BMI, higher %BF, and higher CRP than participants in the lowest tertile of daily television watching time (all Ps ≤ .04).

After adjusting for age, gender, monthly personal income, smoking status, perceived stress, and %BF, time spent watching television was inversely associated with adjusted telomere length (–71.70 bp; SE = 34.21; P = .04; Table 3). This negative association remained significant even when adjusting for energy intake and MVPA energy expenditure concurrently. For every 1-hour increment in television watching, the mean telomere length decreased by 71.75 bp (–71.75 bp; SE = 34.40; P = .04). However, after classifying participants into 3 age groups, the relation of television watching and telomere length was only observed in adults aged 20 to 40 years (Figure 1). Adults aged 20 to 40 years with longer television watching time had 4.0% shorter telomere length in the full adjusted models (P = .03). We found no association of time spent using a computer or phone and total sedentary behavior time with telomere length in the present analysis (Table 3).

The relation of MVPA energy expenditure to telomere length was also assessed. Energy expended on MVPA was not associated with telomere length among adults across all age groups (Table B, available as a supplement to the online version of this article).

DISCUSSION

This study is the first to our knowledge to examine the association between sedentary behavior and telomere length among Chinese adults. Our key finding is that Chinese adults who spent more time on watching television had a shorter telomere

TABLE 2—Study Sample by Tertiles of Time Spent Television Watching: Chengdu, Guizhou, and Xiamen, China; September 2013–2015

Characteristic	Daily Time Spent on Watching Television: Tertile 1, No. (%) or Median (IQR)	Tertile 2, No. (%) or Median (IQR)	Tertile 3, No. (%) or Median (IQR)	*P*
Television watching, hr/d	0.41 (0.00, 0.73)	2.00 (1.50, 2.00)	3.00 (2.50, 4.00)	
No. (%)	192 (37.07)	152 (29.34)	174 (33.59)	
Age, y	43.16 (32.34, 51.20)	49.88 (40.07, 58.16)	50.75 (40.40, 60.05)	≤ .001
Female	105 (54.69)	87 (57.24)	89 (51.15)	.5
Leokocyte telomere length, base pairs	6591.28 (5903.03, 7154.88)	6305.53 (5829.97, 6979.91)	6265.54 (5768.16, 6817.93)	.02
C-reaction protein, mg/L	2.00 (1.10, 4.55)	3.65 (1.65, 5.20)	4.45 (2.40, 5.00)	≤ .001
MVPA energy expenditure,[a] MJ/d	2.86 (1.70, 4.65)	2.63 (1.54, 4.63)	2.65 (1.31, 4.40)	.4
Total energy intake, MJ/d	6.16 (4.82, 7.60)	6.48 (5.20, 8.08)	6.23 (5.04, 7.82)	.2
Anthropometric data				
Overweight,[b]	63 (32.81)	63 (41.45)	67 (38.51)	.2
Body mass index, kg/m^2	23.28 (21.03, 25.76)	24.10 (21.87, 26.04)	24.11 (21.51, 26.07)	.04
% body fat[c]	29.83 (25.03, 35.48)	33.25 (26.89, 38.64)	31.83 (25.55, 38.40)	.01
Sociodemographic data				
High personal income per month[d]	69 (35.93)	63 (41.45)	59 (33.91)	.1
High education level[e]	92 (47.92)	49 (32.24)	48 (27.75)	.001
Smoking (current)	31 (16.15)	21 (13.82)	47 (27.01)	.01
Stress in life[f] (yes)	80 (41.67)	70 (46.05)	72 (41.38)	.2

Note. IQR = interquartile range; MVPA = moderate to vigorous physical activity. Significant difference between tertiles was tested using the Kruskal–Wallis test for non-normally distributed continuous variables and the χ^2 test for categorical variables. The sample size was n = 518.

[a]MVPA energy expenditure, energy expended on moderate-to-vigorous physical activity (MJ/d).[23]

[b]Body mass index ≥ 25 kg/m^2.[20]

[c]Calculated according to the equations developed by Liu et al.[21]

[d]Personal income per month at least ≥ 3000 RMB, which is moderate level among the general population in Southwest China.[17]

[e]At least 12 years of school education.

[f]Evaluated by 10-item Chinese perceived stress scale.[25]

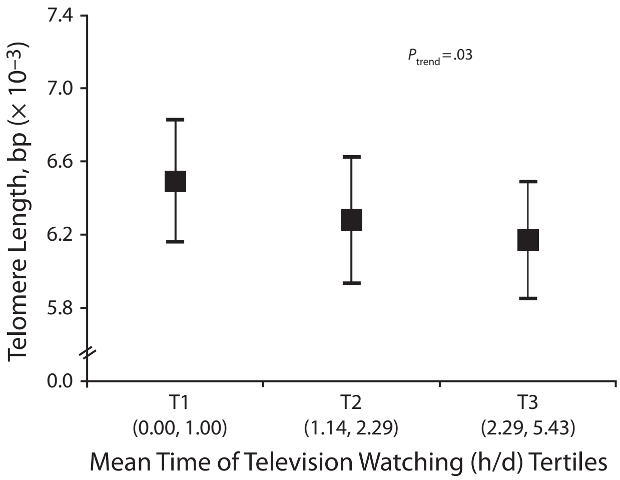
length (adjusted for gender, age, smoking, perceived stress, and %BF) than the participants who watched less television. This relationship between television watching and telomere length remained significant even after adjusting for physical activity and energy intake. Although the association was modest, we found that for every 1-hour increment in television watching, the mean telomere length decreased 72 bp, corresponding to a difference of approximately 1.2 to 1.8 years in biological age, assuming an annual mean telomere length shortening of 40 to 60 bp.[26]

To date, only 2 cross-sectional studies have evaluated the relation of sedentary behavior and telomere length, the National Health and Nutrition Examination Survey[7] and the Nurses' Health Study.[8] The former focused on adults aged 20 to 84 years, revealing that greater leisure-time screen-based sedentary behavior was associated with shorter telomere length,[7] and the latter reported a null relationship between sedentary behavior and telomere length among women aged 43 to 70 years.[8] Unlike these 2 studies, the present study not only focused on the total time spent in sedentary behavior but also considered the relationship between the specific types of screen-based sedentary behavior—that is, television watching and computer and phone use—and telomere length. The

TABLE 3—Multiple Linear Regression for the Association of Time Spent on Television Watching Computer or Phone Use, Screen Time, or Total Sedentary Time With Leukocyte Telomere Length: Chengdu, Guizhou, and Xiamen, China; September 2013–2015

Sedentary Behavior	Leukocyte Telomere Length (bp): Estimate (SE), hr/d	*P* for Trend
Television watching		
Model A	−69.78 (34.12)	.04
Model B	−71.70 (34.21)	.04
Model C	−71.75 (34.40)	.036
Computer/phone use		
Model A	14.22 (18.36)	.4
Model B	13.53 (18.40)	.5
Model C	12.20 (18.47)	.5
Screen-based sedentary time		
Model A	−3.26 (16.39)	.8
Model B	−4.22 (16.45)	.8
Model C	−5.11 (16.56)	.8
Total sedentary time		
Model A	19.66 (15.14)	.2
Model B	19.57 (15.15)	.2
Model C	18.60 (15.22)	.2

Note. bp = base pairs. Values are estimate (SE, standard error). Linear trends (*P* for trend) were obtained with time spent watching television, using a computer or phone, screen-based sedentary behavior (sum of time spent watching television and using a computer or phone) or total sedentary behavior (sum of time spent on sedentary activities) as continuous variables. Model A was adjusted for age, gender, personal income per month, smoking and stress. Model B was the same as model A and was also adjusted for percentage of body fat. Model C was the same as model B and was also adjusted for moderate to vigorous physical activity energy expenditure (MJ/d) and total energy intake (MJ/d). The sample size was n = 518.



Note. T = tertile. Data shown are estimated least-squares means of leukocyte telomere length and 95% confidence interval adjusted for potential confounding factors (model C). Values in the parentheses on the horizontal axis are minimum and maximum.

FIGURE 1—Leukocyte Telomere Length by Tertile of Time Spent Watching Television for Participants Aged 20–40 Years: Chengdu, Guizhou, and Xiamen, China; September 2013–2015

present study showed that total sedentary time, screen-based sedentary time, and computer and phone use time were not related to telomere length. Time spent watching television, a specific type of screen-based sedentary behavior, however, was inversely associated with telomere length. This relationship possibly lies within the concurrent intake of unhealthy foods,[27] which has been suggested to have a significant association with telomere length.[28] In addition, most participants (61%) in the study tended to watch television at night till 10:30 PM, which may affect their sleep quality,[29] an important factor contributing to the shortening of telomere length.[30]

More importantly, the negative relation between television watching and telomere length in the present study was observed only among those individuals aged 20 to 40 years, which means that, if confirmed by prospective and experimental studies, this might be an important age group for which targeted sedentary behavior interventions should be developed, implemented, and evaluated. In addition, telomere length has been reported to remain more stable among older individuals,[31] potentially limiting statistical power in studies of middle-aged and older participants, which could partly explain the null results among the participants aged 41 to 70 years in this analysis.

Sedentary behavior epidemiology is an emerging field; thus, our understanding of the mechanisms through which sedentary behavior influences telomere length at the cellular level is lacking. In conjunction with the determinants of telomere length shortening,[1] the balance between inflammatory and anti-inflammatory response, the hypothesized mechanism to explain the sedentary behavior–telomere length relationship may be sedentary behavior–induced inflammation,[32] which has been supported by the positive association between sedentary behavior and inflammatory factor, for example, CRP in the present study and the modulation of metabolic risk.[32] In brief, the present analysis suggests that time spent watching television may be related to accelerated cell aging. Further examination of how it influences telomere length and whether telomere length mediates the relationship between television watching and age-related diseases is needed.

Our analysis also showed that MVPA energy expenditure was not related to telomere length, which agrees with 1 prospective study reporting null associations among those of White and Danish descent.[11] However, our results did not agree with cross-sectional studies that have mainly linked physical activity with longer telomere length among US,[8,9] UK,[10] and Polish[13] adults or 2 prospective studies suggesting inverted-U–shaped associations among Finnish[12] and US[14] adults. Our results are inconsistent with most existing research, possibly because MVPA among adults in China is too low to observe the relationship between physical activity and telomere length; approximately 82% of adults in China do not meet the World Health Organization recommendation[5] (about 45% of those in the United States[33] and 28.6% in European countries[34]). These inconsistencies may also be due partly to differences in physical activity assessment, covariate adjustment, and study populations, as well as limitations in sample size. Although our analyses consisted of almost all age groups (20–70 years), our small sample size may decrease the statistical power needed to detect the association between physical activity and telomere length. The unexpected finding of a null association between MVPA and telomere length warrants further investigation.

Unlike sedentary behavior, work has been done to explain the mechanism for the relationship between physical activity and telomere length. Oxidative stress and inflammation accelerate telomere attrition[1] and, therefore, potentially mediate the association between physical activity and telomere length; moderate amounts of regular activity generate low levels of reactive oxygen species, inducing adaptive increases in endogenous antioxidant defenses, whereas high amounts of activity generate excess reactive oxygen species that counteract these defenses.[35] Physical activity possibly helps to lower the level of inflammation, which overlaps the signals path with oxidative stress. Reactive oxygen species can initiate inflammation by damaging macromolecules; reactive oxygen species are also products of the inflammatory process.[35]

Strengths and Limitations

Several strengths of our study deserve mention: detailed assessment of sedentary behavior, activity, energy intake, and lifestyle variables collected by trained investigators in face-to-face interviews, and some specific types of screen-based sedentary behavior (television watching and computer and phone use) identified as independent variables. In addition, the Southern blot technique, the most established and accurate method to date,[15] was used to assess the absolute length of telomeres, although it is rarely applied in large-scale testing because of the large workload. A further strength lies in the adjustment for a number of confounders that potentially affected the associations between sedentary behavior or physical activity and telomere length, particularly socioeconomic indices, smoking status, physical activity and sedentary behavior, anthropometric measures, and energy intake.

Owing to the cross-sectional design of this study, we were unable to observe the causality of the effect of sedentary behavior and physical activity on telomere length. Conceivably, individuals with shorter telomeres may have chronic diseases that reduce their ability to exercise and increase their time spent in sedentary activities. However, this was unlikely because our results were similar after excluding individuals who were diagnosed with heart disease, diabetes, or hypertension (Table F, available as a supplement to the online version of this article). Third, our results regarding the relationship between MVPA and telomere length were inconsistent with those of most studies, which might limit our study's generalizability. Unmeasured or residual confounding remains a possibility, although adjustment for sociodemographic, lifestyle, and dietary factors did not appreciably alter our results.

Public Health Implications

Our data indicate that television watching is inversely related to telomere length among Chinese adults, independent of %BF, physical activity, and energy intake. These associations are more pronounced in adults aged 20 to 40 years. Further studies should be conducted to explore dose–response relationships and causality to confirm our results. Nevertheless, our findings have important implications for public health, suggesting that television watching may play a significant role in the development and prevention of cellular aging. Consideration should be given to including strategies to reduce the amount of television watching in aging-specific prevention programs. AJPH

CONTRIBUTORS

H.-m. Xue and Q.-q. Liu contributed equally to this study and share first authorship. H.-m. Xue conducted the analyses and wrote the article. Q.-q. Liu conducted the Southern blot technique. G. Tian and L.-m. Quan provided dietary data and critical input on the data analyses. Y. Zhao and G. Cheng designed the study. G. Cheng also conceptualized the project. All authors approved the final version of the article.

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HUMAN PARTICIPANT PROTECTION

The Ethics Committee of Sichuan University approved the study. All participants provided written informed consent for all examinations.

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