THE JOURNAL OF
SEXUAL MEDICINE

ORIGINAL RESEARCH & REVIEWS

EPIDEMIOLOGY & RISK FACTORS

Trends in Sexual Activity and Associations With All-Cause and Cause-Specific Mortality Among US Adults

Chao Cao, MPH,[1,2] Lin Yang, PhD,[3,4] Tianlin Xu, MPH,[5] Patricia A. Cavazos-Rehg, PhD,[6] Qinran Liu, MPH,[7] Daragh McDermott, PhD,[8] Nicola Veronese, MD,[9] Thomas Waldhoer, PhD,[10] Petre Cristian Ilie, MD, PhD, MBA,[11] Shahrokh F. Shariat, MD,[12] and Lee Smith, PhD[13]

ABSTRACT

Background: Sexual activity can be referred to as a health behavior and may also act as an indicator of health status.

Aim: To evaluate temporal trends in sexual activity and to examine associations of sexual activity with all-cause and cause-specific mortality risk.

Methods: We examined the trends and prevalence of sexual activity and association of sexual activity with all-cause and cause-specific mortality in a nationally representative sample using data from the US National Health and Nutrition Examination Survey from 2005 to 2016 and the National Health and Nutrition Examination Survey 2005-2014 Linked Mortality File (through December 31, 2015).

Outcomes: All-cause, cardiovascular disease, and cancer mortality.

Results: A total of 15,269 US adults (mean age, 39.1 years [standard error, 0.18 years]) were included in the trend analysis. In the 2015-2016 cycle, while 71.7% (95% CI, 67.7−75.7%) US adults aged 20-59 years engaged in sexual activity ≥ 12 times/year (monthly), only 36.1% (95% CI, 31.6−40.7%) of them engaged in sexual activity ≥ 52 times/year (weekly). Since the 2005−2006 cycle, the estimated prevalence of sexual activity, ≥52 times/year and ≥12 times/year, were both stable over time among overall and each age group (all P for trend >0.1). During a median follow-up of 5.7 years (range, 1−11 years) and 71,960 person-years of observation, among 12,598 participants with eligible information on mortality status, 228 deaths occurred, including 29 associated with cardiovascular disease and 62 associated with cancer. Overall, participants with higher sexual activity frequency were at a lower risk of all-cause death in a dose-response manner (P for trend = 0.020) during the follow-up period. In addition, the multivariable-adjusted hazard ratios for all-cause mortality, CVD mortality, cancer mortality, and other cause mortality among participants who had sex ≥52 times/year compared with those having sex 0−1 time/year were 0.51 (95% CI, 0.34 to 0.76), 0.79 (95% CI, 0.19 to 3.21), 0.31 (95% CI, 0.11 to 0.84), and 0.52 (95% CI, 0.28 to 0.96), respectively.

Clinical Implications: Sexual activity appears to be a health indicator of all-cause and cancer mortality in US middle-aged adults.

Strengths & Limitations: Clear strengths of the present study include the large representative sample of the noninstitutionalized US population as well as the identification of precise estimates in relation to sexual activity

Received March 30, 2020. Accepted May 25, 2020.

[1]Program in Physical Therapy, Washington University School of Medicine, St Louis, MO, USA;

[2]Center for Human Nutrition, Washington University School of Medicine, St Louis, MO, USA;

[3]Department of Cancer Epidemiology and Prevention Research, Alberta Health Services, Calgary, Canada;

[4]Departments of Oncology and Community Health Sciences, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada;

[5]Department of Biostatistics, School of Public Health, The University of Texas Health Science Center at Houston, Houston, TX, USA;

[6]Department of Psychiatry, Washington University School of Medicine, St. Louis, MO, USA;

[7]Division of Public Health Sciences, Department of Surgery, Washington University School of Medicine, St Louis, MO, USA;

[8]Division of Psychology, School of Psychology and Sports Sciences, Anglia Ruskin University, Cambridge, UK;

[9]Department of Internal Medicine and Geriatrics, University of Palermo, Palermo, Italy;

[10]Department of Epidemiology, Center for Public Health, Medical University of Vienna, Vienna, Austria;

[11]Queen Elizabeth Hospital Foundation Trust, King's Lynn, UK;

[12]Department of Urology, Medical University of Vienna, Vienna, Austria;

[13]The Cambridge Centre for Sport and Exercise Sciences, Anglia Ruskin University, Cambridge, UK

https://doi.org/10.1016/j.jsxm.2020.05.028

and mortality. However, because of the observational nature of the study design, causality could not be determined.

Conclusions: Sexual activity was found to be associated with a lower risk of mortality from all cause and cancer.
Cao C, Yang L, Xu T, et al. Trends in Sexual Activity and Associations With All-Cause and Cause-Specific Mortality Among US Adults. J Sex Med 2020;17:1903−1913.

Key Words: Sexual Health; NHANES; Cancer; Mortality; Sexual Activity

INTRODUCTION

Sexual health is defined by the World Health Organization as "a state of physical, emotional, mental, and social well-being related to sexuality, not merely the absence of disease dysfunction or infirmity."[1] Sexual activity can encompass a plethora of acts including penetrative sex (vaginal, anal), oral sex, and mutual masturbation.[1] In the United States, a study reported that the average adult engages in sexual activity 54 times a year or about once a week in 2014.[2] Although cross-sectional data suggested that sexual frequency declined among adults married or living together with their partners,[3] data on the secular trends in sexual activity are scarce.

Most literature to date has focused on the negative aspects of sexual activity, specifically sexually transmitted infections. Specifically, the prevalence of human papillomavirus infection, a key risk factor of cervical cancer,[4] can range from 19% to 46% in sexually active young females.[5] In addition, human papillomavirus is a risk factor for cancers of the penis, mouth, and anus.[4] Infection-cancer association also exits for gonorrhea infection,[6] hepatitis B and C,[7] and HIV.[8] In addition, sexually transmitted infections have also been associated with diseases of the cardiovascular system.[9] Negative health consequences have also been associated with sexual dysfunction, consequently a reduction in sexual activity. Erectile dysfunction in men was prospectively associated with incident cancer, coronary heart disease, and fair/poor self-rated health.[10] In women, cross-sectional associations were exhibited between the inability to become sexually aroused and higher odds of stroke.[10] Importantly, associations between sexual dysfunctions and male infertility or unfavorable sperm parameters have also been reported.[11,12] Finally, increased early sexual activity in young or new couples often parallel addictive neural cognitive pathways that may have negative consequences on health.[13] However, as a relationship matures, the mutual excitement of new sexual activity evolves into one of less risk and more toward trust and exclusivity, which may lead to better health.[13]

With respect to the frequency of sexual activity, studies have shown higher sexual activity was linked to lower physical health.[14−16] Nevertheless, frequent sexual intercourse has been associated with reduced risk of fatal coronary events and breast cancer[17,18] and with greater enjoyment of life,[19] quality of life,[20] well-being,[21] and cognitive function,[22,23] suggesting a protective effect of sexual activity.

Few studies that examined the association between sexual activity and early mortality produced mixed results. One study showed that teenage sexual activity was predictive of increased mortality risk across the life span.[24] However, the same study found that the frequency of orgasm for married females was found to be somewhat protective against early mortality risk.[24] Another study found the sexual activity to be inversely related to mortality, and men having high libido was also associated with lower mortality.[25] These mixed findings require future research in large nationally representative samples to shed light on the relationship between sexual activity and mortality. Moreover, it is important to examine in detail the contemporary prevalence of sexual activity and the secular trend over time to provide information about the sexual frequency of societies.

Therefore, the present study aims to evaluate the prevalence and trends of sexual activity in the United States and to investigate the association between sexual activity and mortality in the United States using nationally representative data.

METHODS

Study Population and Design

The National Health and Nutrition Examination Survey (NHANES), described in detail elsewhere,[26] is a nationally representative series of surveys and physical examinations conducted by the Centers for Disease Control and Prevention. It was designed to evaluate the health and nutritional status of residents in the United States and was approved by the National Center for Health Statistics Ethics Review Board. Written consent was provided by each participant.[27] Starting in the 2005−2006 cycle, NHANES added questions on the times of sex to the sexual behavior questionnaire. For trends in sexual activity, we combined data sets from 2005 to 2016, where the sexual behavior questionnaire contained information regarding sexual frequency on individuals aged 20 to 59 years, following NHANES technical guidelines.

Assessment of Sexual Activity

The frequency of sexual activities was self-reported during the in-person interview.[28] Participants were asked, "In the past 12 months, about how many times have you had vaginal or anal sex?" with options of never, once, 2−11 times, 12−51 times, 52−103 times, 104−364 times, and 365 times or more in the

past 12 months. For analysis on trends in sexual activity, participants' responses were further categorized into 2 dummy variables: (i) having sexual activity ≥ weekly, which includes participants who reported a frequency of 52 times or higher in the past 12 months and (ii) having sexual activity ≥ monthly, which includes participants who reported having sexual frequency 12 to 51 times in the past 12 months. For analysis of the association between sexual activities and mortality outcomes, we categorized participants into ≤1 time/y, 2-51 times/y, and ≥52 times/y. We used these cutoffs because previous studies found that the average frequency of sexual activity is 54 times/year or about once a week among the US adults,[2] which also approximated the median values in the present study population. In the stratification analysis, no regular sexual activity was defined as having sexual activity ≤1 time/y.

Ascertainment of Mortality

To examine the association of sexual frequency in relation to the risk of all-cause and cause-specific mortality, we ascertained mortality status by linking the NHANES 2005−2014 data to the National Death Index with a probabilistic matching algorithm.[29] The causes of deaths were classified according to the codes of International Statistical Classification of Diseases, 10th revision. In this analysis, our outcomes of interest were mortality from all causes, cardiovascular diseases (CVDs; codes I00-I09, I11, I13, and I20-I51), cancer (codes C00-C97), and other causes. Participants' duration of follow-up was defined as the interval from the interview to their date of death or to the date they were censored (December 31, 2015).[30]

Assessment of Sociodemographic and Lifestyle Factors and Comorbidity Conditions

Self-reported sociodemographic data, including age, sex, race/ethnicity, educational attainment, income level, and lifestyle factors, including smoking status and physical activity, were collected during household interviews via standardized questionnaires.[27] Participants' body weight was obtained from their physical examinations at a mobile examination center. Participants' race/ethnicity was defined as non-Hispanic white, non-Hispanic black, Hispanic, and others based on categories provided by the National Center for Health Statistics. Educational attainment was categorized into 3 categories (less than high school graduate, high school graduate or General Educational Development, or some college or above). Body weight and height were measured during the physical examination, and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Family income was measured as the ratio of family income to the Federal Poverty Line and categorized into 3 levels (<1.30, 1.30-<3.50, or ≥3.50).[31] Smoking status was assessed in adults only and classified into 3 categories (never, former, and current smokers). Physical activity in adults was defined as active if participants had any moderate or vigorous physical activity at leisure time and defined as inactive if otherwise. Chronic disease conditions were defined if participants reported that they had ever been told by a health-care professional that they had CVDs, cancer, and diabetes and/or to take medications because of these conditions.[32] Finally, the participants reported their general health condition with options of excellent, very good, good, fair, and poor.

Statistical Analysis

All analyses considered sample weights, strata, and cluster design variables to account for the complex NHANES design as guided by the National Center for Health Statistics.[33] Weighted mean and percentages of covariates were calculated for NHANES 2015−2016. Weighted estimated prevalence and 95% CI of sexual frequency variables were calculated by age groups and year cycles. Crude linear trends in the prevalence of sexual activity were evaluated using linear regression models across survey cycles and to estimate regression coefficients (β) and 95% CIs for every 2-year change. P for trends were estimated using the survey cycle as a continuous variable. Absolute differences in the estimated prevalence of sexual activity were calculated by comparing the 2015−2016 cycle with the 2005−2006 cycle.

Multivariable logistic regression was used to model prevalence of sexual activity and estimate the odds ratios (ORs) and 95% CI. Sociodemographic and lifestyle correlates for sexual activity over time were identified using multivariable regression models adjusting for age, sex, marital status, race/ethnicity, education attainment, family poverty ratio, leisure-time physical activity, alcohol intake, BMI, smoking status, hypertension, hypercholesterolemia, history of diabetes, history of CVD, and history of cancer.

To identify the association between sexual frequency and all-cause and cause-specific mortality, multivariable-adjusted Cox proportional hazards regression model was used to estimate the hazard ratios (HRs) and 95% CI. Participants with a history of CVD or cancer were excluded when the outcome is the corresponding cause-specific mortality. We adjusted for age, sex, marital status, race/ethnicity, education attainment, and family poverty ratio in model 1 and adjusted for all the listing covariates in model 2. We additionally adjusted the general health condition in model 3. For the HRs, we classified the participants into 3 groups (0−1 times, 2−51 times, and ≥52 times) based on their sexual frequency in the past 12 months. Furthermore, we performed stratified analyses and interaction analyses to examine whether the association of sexual activity frequency with all-cause mortality differed by age, sex, marital status, leisure-time physical activity, BMI, smoke status, and chronic diseases, which correlated with sexual activity. Finally, we conducted the sensitivity analysis excluding the participants with a history of CVD or cancer at baseline. Statistical analysis was performed with SAS, version 9.4, and STATA, version 15, and the P value for the statistical tests was 2-sided, with statistically significant values considered as $P < .05$. P values were not adjusted for multiple tests.

Table 1. Sample size for sexual frequency among US adults by sociodemographic and lifestyle characteristics, NHANES 2015-2016

	No. of participants by annual sexual frequency (weighted %)							
Subgroup	0 time	1 time	2–11 times	12–51 times	52–103 times	104–364 times	≥365 times	Overall
Overall	96 (3.0)	121 (3.4)	584 (21.9)	917 (35.6)	526 (21.8)	343 (13.7)	24 (0.7)	2,611 (100)
Age group								
20–39 years	42 (2.2)	54 (3.0)	254 (17.0)	451 (32.9)	316 (25.6)	229 (18.6)	13 (0.7)	1,359 (100)
40–59 years	54 (3.8)	67 (3.9)	330 (26.7)	466 (38.2)	210 (18.0)	114 (8.9)	11 (0.6)	1,252 (100)
Sex								
Male	62 (4.0)	63 (3.5)	266 (20.4)	445 (35.1)	272 (22.8)	181 (13.6)	15 (0.8)	1,304 (100)
Female	34 (2.0)	58 (3.4)	318 (23.4)	472 (36.1)	254 (20.7)	162 (13.9)	9 (0.5)	1,307 (100)
Marital status								
Single/separed	39 (3.2)	67 (6.3)	260 (30.7)	278 (31.8)	123 (16.9)	76 (10.4)	8 (0.7)	851 (100)
Married/lived with partner	57 (2.9)	54 (2.2)	324 (18.2)	639 (37.1)	403 (23.8)	267 (15.1)	16 (0.6)	1760 (100)
Race/ethnicity								
Non-Hispanic white	24 (2.3)	20 (2.2)	179 (21.7)	287 (36.3)	193 (23.2)	128 (14.0)	5 (0.4)	836 (100)
Non-Hispanic black	24 (4.0)	45 (7.6)	141 (23.6)	216 (36.4)	96 (16.6)	61 (10.7)	7 (1.1)	590 (100)
Hispanic	36 (4.5)	42 (5.3)	164 (20.4)	238 (30.0)	174 (22.8)	117 (15.8)	10 (1.3)	781 (100)
Other*	12 (3.5)	14 (3.3)	100 (23.3)	176 (40.0)	63 (16.7)	37 (12.4)	2 (0.7)	404 (100)
Family poverty ratio								
<1.3	34 (5.2)	44 (5.4)	160 (21.9)	219 (30)	122 (19.1)	89 (16.4)	13 (2.0)	681 (100)
1.3–<3.5	37 (3.5)	38 (3.5)	209 (20.8)	352 (34.4)	206 (23.5)	135 (14.1)	6 (0.3)	983 (100)
≥3.5	17 (1.5)	25 (2.3)	160 (22)	295 (40.6)	155 (21.2)	98 (12.3)	3 (0.3)	753 (100)
Educational attainment								
<High school	35 (7.3)	44 (8.9)	115 (22.7)	131 (30.7)	82 (16.6)	54 (12.2)	11 (1.8)	472 (100)
High school	24 (3.9)	25 (2.8)	136 (23.3)	179 (31.6)	106 (20.7)	89 (16.7)	8 (1.1)	567 (100)
>High school	37 (2)	52 (2.6)	333 (21.3)	607 (37.6)	338 (23)	200 (13.2)	5 (0.3)	1,572 (100)
Weight status								
<25 kg/m^2	27 (3.8)	39 (3.4)	148 (18.4)	288 (36.5)	159 (24.6)	92 (13.0)	4 (0.4)	757 (100)
25–<30 kg/m^2	25 (2.4)	37 (3.9)	188 (23.0)	273 (37.3)	149 (20.3)	107 (12.4)	10 (0.7)	789 (100)
≥30 kg/m^2	42 (2.8)	44 (3.0)	247 (23.8)	352 (33.4)	215 (20.8)	143 (15.4)	10 (0.8)	1,053 (100)
Leisure-time physical activity†								
Inactive	52 (3.8)	63 (5.2)	295 (26)	381 (33.3)	203 (18.9)	125 (12.0)	14 (0.8)	1,133 (100)
Active	44 (2.5)	58 (2.3)	289 (19.3)	536 (37.0)	323 (23.5)	218 (14.8)	10 (0.6)	1,478 (100)
Smoke status								
Never	50 (2.7)	62 (2.6)	364 (21.7)	583 (38.4)	321 (21.8)	189 (12.2)	10 (0.5)	1,579 (100)
Past	14 (2.7)	15 (2.5)	84 (20.7)	148 (32.9)	105 (25.5)	68 (15.2)	3 (0.5)	437 (100)
Current	32 (4)	44 (6.5)	135 (23.3)	185 (30.3)	100 (18.3)	86 (16.5)	11 (1.1)	593 (100)

(continued)

Table 1. Continued

Subgroup	No. of participants by annual sexual frequency (weighted %)							
	0 time	1 time	2–11 times	12–51 times	52–103 times	104–364 times	≥365 times	Overall
Chronic diseases[‡]								
No	70 (2.2)	102 (3.2)	483 (20.8)	808 (36.2)	469 (22.3)	314 (14.6)	18 (0.6)	2,264 (100)
Any	26 (8.7)	19 (4.9)	101 (29.3)	109 (30.7)	57 (17.6)	29 (7.7)	6 (1.2)	347 (100)

NHANES = National Health and Nutrition Examination Survey.
*"Other" includes race/ethnicity other than non-Hispanic white, non-Hispanic black, and Hispanic, including multiracial.
†Leisure-time physical activity level was defined by engaging in no (inactive) or any (active) moderate or vigorous recreational physical activity over the past 30 days (2005–2006) or in a typical week (2007–2016).
‡Chronic diseases included cardiovascular diseases, cancer, and diabetes.

RESULT

Participant Characteristics

A total of 15,269 US adults (mean age, 39.1 years [standard error, 0.18 years]) were included in the present analysis, including 7,765 males and 7,504 females. Table 1 demonstrated the characteristics of study participants in the 2015−2016 cycle according to sexual activity frequency. Most participants had sexual activity from 2−11 times/y to 52−103 times/y. In particular, 6.4% adults had sexual activity ≤1 times/y, whereas 14.4% adults had sexual activity ≥104 times/y. Participants with sexual activities ≤1 times/y were more likely to be younger, single/separated, non-Hispanic black, and current smokers and to have lower income level, education attainment, physical activity level, and chronic diseases. There was no significant difference in annual sexual activity frequency between males and females ($P = .101$).

Trends and Prevalence of Sexual Activity

In the 2015−2016 cycle, while 71.7% (95% CI, 67.7−75.7%) (estimated 88.2 million) US adults aged 20−59 years had sexual activity at least once a month, only 36.1% (95% CI, 31.6−40.7%) (estimated 44.5 million) of them had sexual activity at least once a week (Table 2). The estimated prevalence of sexual activity among adults aged 20-39 years was higher than the prevalence among adults aged 40-59 years (≥weekly: 44.9% [95% CI, 39.5−50.2%] vs 27.4% [95% CI, 23.1−31.7%]; ≥monthly: 77.8% [95% CI, 72.9−82.7%] vs 65.6% [95% CI, 60.7−70.5%]). Since the 2005-2006 cycle, the estimated prevalence of sexual activity both ≥weekly and ≥monthly was stable over time among the overall sample and each age group (all P for trend >0.10).

After multivariable adjustments, we observed an apparent racial disparity in regular sexual activity, and non-Hispanic whites were more likely to have sex than other race/ethnicity groups. The prevalence of sexual activity was decreased as age increased (≥weekly: OR, 0.96 [95% CI, 0.95 to 0.96]; ≥monthly: OR, 0.96 [95% CI, 0.95 to 0.96]). In addition, the lower prevalence of sexual activity was found among adults without a history of smoking, inactive individuals, and those with chronic diseases than among their counterparts. Of note, adults with high economic status had a higher chance of achieving monthly sexual activity (P for trend = 0.007) rather than weekly sexual activity (P for trend = 0.002). The education level was only positively associated with prevalence of sexual activity ≥ monthly (P for trend<0.001). (For all estimates, see Supplementary Table 1).

Sexual Activity and Mortality

During a median follow-up of 5.7 years (range, 1−11 years; interquartile range, 4.8 years) and 71,960 person-years of observation, among 12,598 participants with eligible information on mortality status, 228 deaths occurred (weighted

Table 2. Weighted trends in sexual activity among US adults, NHANES 2005-2016*

	Trends in sexual activity frequency							2015-2016 vs 2005-2006
Age, y	2005-2006	2007-2008	2009-2010	2011-2012	2013-2014	2015-2016	*P* for trend†	Difference (95% CI)‡
≥52 Times/y(weekly), weighted % (95% CI)								
Overall	38.1	34.7	37.1	35.7	35.7	36.1	0.618	−1.9
	(34.2 to 41.9)	(32.4 to 37.0)	(35 to 39.2)	(32.6 to 38.8)	(32.8 to 38.5)	(31.6 to 40.7)		(−7.6 to 3.8)
20−39	46.0	42.7	46.7	44.2	41.8	44.9	0.562	−1.1
	(41.4 to 50.6)	(40.1 to 45.3)	(44 to 49.4)	(39.1 to 49.3)	(37.7 to 46)	(39.5 to 50.2)		(−7.9 to 5.6)
40−59	29.9	26.6	27.8	27.0	29.2	27.4	0.772	−2.5
	(25.1 to 34.8)	(23.1 to 30.1)	(24.3 to 31.2)	(24 to 30)	(25.9 to 32.5)	(23.1 to 31.7)		(−8.7 to 3.7)
≥12 Times/y (nonthly), weighted % (95% CI)								
Overall	74.4	71.5	70.0	68.5	71.1	71.7	0.291	−2.7
	(70.8 to 78)	(68.5 to 74.5)	(67.3 to 72.7)	(64.4 to 72.7)	(69.3 to 72.9)	(67.7 to 75.7)		(−7.9 to 2.5)
20−39	80.7	78.0	77.0	77.0	75.8	77.8	0.178	−2.9
	(77.6 to 83.7)	(75 to 81.1)	(73.6 to 80.3)	(74.7 to 79.3)	(72.7 to 78.8)	(72.9 to 82.7)		(−8.4 to 2.6)
40−59	68.0	64.9	63.2	59.9	66.2	65.6	0.619	−2.3
	(63 to 73)	(60.4 to 69.5)	(59.9 to 66.5)	(52.7 to 67.1)	(62.8 to 69.6)	(60.7 to 70.5)		(−9.0 to 4.3)

NHANES = National Health and Nutrition Examination Survey.

*Weighted estimates and 95% CIs were estimated for each survey cycle. All estimates were weighted to be nationally representative.

†P for trend were calculated using linear regression that included the NHANES 2-year cycle as a continuous variable.

‡A decrease corresponds to difference below zero.

death = 1,794,391), including 29 associated with CVD (weighted death = 205,974) and 62 associated with cancer (weighted death = 513,079). Overall, after adjusting for a range of sociodemographic characteristics, lifestyle behaviors, and chronic diseases, participants with higher sexual activity frequency were at a lower risk of all-cause death in a dose-response manner (P for trend = 0.020) during the follow-up period (Figure 1 and Table 3; for HRs for each category of sexual activity, see Supplementary Table 2). In addition, the multivariable-adjusted HRs for all-cause mortality, CVD mortality, cancer mortality, and other cause mortality among participants who had sex ≥52 times per year compared with those having sex 0-1 times per year were 0.51 (95% CI, 0.34 to 0.76), 0.79 (95% CI, 0.19 to 3.21), 0.31 (95% CI, 0.11 to 0.84), and 0.52 (95% CI, 0.28 to 0.96), respectively. The associations were similar when participants with CVD or cancer at baseline were excluded (Supplementary Figure 1 and Supplementary Table 3).

Stratified analyses on associations of sexual activity with all-cause mortality by age, sex, marital status, leisure-time physical activity, BMI, smoking status, and chronic diseases are illustrated in Figure 2. Stronger associations appeared among individuals with any chronic diseases (CVD, cancer, and diabetes) than among individuals who were free of chronic diseases (HR, 0.25 [95% CI, 0.15 to 0.42] vs 0.88 [95% CI, 0.53 to 1.45]; *P* for interaction = 0.005). The association did not significantly differ by age, sex, marital status, leisure-time physical activity, BMI, and smoking status.

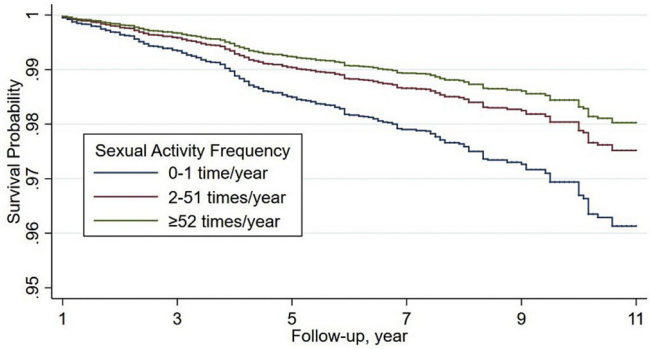

Figure 1. Survival curve by sexual frequency among US adults. Survival curves illustrating the association between sexual frequency and all-cause mortality. Survival curves were adjusted for age, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and other), education attainment (less than high school, high school graduate, above high school), family poverty ratio (<1.30, 1.30-3.49, or ≥3.5), physical activity (active/inactive), alcohol consumption (0, 0.1-4.9, 5-14.9, 15-29.9, or ≥30 g/d), BMI, smoking status (never smoking, past <20 pack-years, past ≥20 pack-years, past without pack-year information, current < 20 pack-years, and current ≥ 20 pack-years), hypertension (yes/no), hypercholesterolemia (yes/no), diabetes (yes/no), history of CVD (yes/no), history of cancer (yes/no), and general health condition (poor, fair, good, very good, and excellent). Figure 1 is available in color online at www.jsm.jsexmed.org.

DISCUSSION

In the present study including a large representative sample of noninstitutionalized US adults, it was found that the prevalence of sexual activity (weekly: ≥52 times/y; monthly ≥12 times/y) was stable among US adults aged 20−59 years from the 2005−2006 cycle to the 2015−2016 cycle. Moreover, in the 2015−2016 cycle, 71.7% of adults had sex monthly and 36.1% had sex weekly, and the prevalence of sexual activity decreased with age; these findings provide US population norms for sexual activity and may be used as reference data to compare individuals with specific conditions to normative data for the general population. Then, the present study found that participants with higher sexual frequency were at a lower risk of all-cause mortality, CVD mortality, and cancer mortality, in a dose-response manner.

Findings from the present study support, through identifying similar sexual activity prevalence estimates and a decline in sexual activity with age, and add to, by showing that the prevalence of sexual activity is stable over time, previous literature investigating the prevalence of sexual activity in the US population.[3]

In light of the wider literature regarding the positive physical and mental health benefits relating to frequent sexual activity, the present finding of relatively high and stable estimates of sexual activity are encouraging. However, the decline in sexual activity in aging adults should be noted and supports several previous studies.[34,35] As several studies have shown positive physical[14−16] and mental health[19−23] benefits in relation to sexual activity in older adults, physicians should be mindful that the relationship between physical health and sexual activity may be reciprocal and that a decline in sexual activity may indicate ill health. Indeed, the development of interventions to promote sexual health and well-being at older ages may offer considerable opportunities to reduce the burden of disease in later life as our findings indicate that this bidirectional relationship between sexual activity and physical health is significant and continues throughout the lifespan.

The finding that participants with higher sexual frequency are at a lower risk of mortality in a dose-response manner supports previous findings albeit in smaller samples.[24,25] The protective effect against early mortality is likely owing to 2 overarching hypothesizes. First, sexual activity is associated with positive physical and mental health benefits likely resulting in a reduction in disease burden within this population. Second, those who are suffering ill health may be less likely to engage in sexual activity potentially owing to their burdensome condition(s).

Several mechanisms may explain the association between sexual activity and better physical and mental health. First, sexual activity may be a form of physical activity, a study carried out in a young and healthy population showed that the mean energy expenditure during sexual activity was 101 kCal or 4.2 kCal/min in men and 69.1 kCal or 3.1 kCal/min in

Table 3. Association of sexual activity frequency with all-cause and cause-specific mortality among US adults

Subgroup	No./total no.	Weighted death (%)	Hazard ratio (95% CI)		
			Model 1*	Model 2*,†	Model 3*,†,‡
Any cause mortality					
0–1 times/y	50/1,183	386,165 (4.2)	1 [Reference]	1 [Reference]	1 [Reference]
2–51 times/y	60/2,748	478,237 (1.9)	0.61 (0.37 to 1.00)	0.64 (0.40 to 1.02)	0.64 (0.41 to 0.99)
≥52 times/y	118/8,667	929,989 (1.1)	0.46 (0.30 to 0.69)	0.47 (0.31 to 0.72)	0.51 (0.34 to 0.76)
P for trend§			0.007	0.009	0.020
CVD mortality‖					
0–1 times/y	6/1,109	46,839 (0.5)	1 [Reference]	1 [Reference]	1 [Reference]
2–51 times/y	3/2,591	12,165 (0.1)	0.17 (0.03 to 0.91)	0.20 (0.04 to 1.11)	0.20 (0.03 to 1.22)
≥52 times/y	11/8,427	100,028 (0.1)	0.62 (0.16 to 2.41)	0.76 (0.18 to 3.20)	0.79 (0.19 to 3.21)
P for trend§			0.412	0.599	0.638
Cancer mortality¶					
0-1 times/y	10/1,146	100,669 (1.1)	1 [Reference]	1 [Reference]	1 [Reference]
2–51 times/y	12/2,657	95,033 (0.4)	0.39 (0.12 to 1.24)	0.35 (0.11 to 1.15)	0.37 (0.11 to 1.18)
≥52 times/y	31/8,418	232,200 (0.3)	0.36 (0.13 to 1.00)	0.30 (0.11 to 0.81)	0.31 (0.11 to 0.84)
P for trend§			0.162	0.069	0.077
Other cause mortality					
0–1 times/y	32/1,183	212,186 (2.3)	1 [Reference]	1 [Reference]	1 [Reference]
2–51 times/y	35/2,748	310,605 (1.2)	0.72 (0.41 to 1.27)	0.75 (0.44 to 1.28)	0.73 (0.43 to 1.23)
≥52 times/y	70/8,667	552,547 (0.7)	0.47 (0.25 to 0.88)	0.48 (0.25 to 0.93)	0.52 (0.28 to 0.96)
P for trend§			0.167	0.204	0.290

BMI = body mass index; CVD = cardiovascular disease.
*Adjusted for age, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and other), education attainment (less than high school, high school graduate, above high school), and family poverty ratio (<1.30, 1.30–3.49, or ≥3.5).
†Additionally adjusted for physical activity (active/inactive), alcohol consumption (0, 0.1–4.9, 5–14.9, 15–29.9, or ≥30 g/d), BMI, smoking status (never smoking, past <20 pack-years, past ≥20 pack-years, past without pack-year information, current < 20 pack-years, and current ≥ 20 pack-years), hypertension (yes/no), hypercholesterolemia (yes/no), diabetes (yes/no), history of CVD (yes/no), and history of cancer (yes/no).
‡Additionally adjusted for general health condition (poor, fair, good, very good, and excellent).
§P for trend was calculated using the annual sexual frequency (none, 1 time, 2–11 times, 12–51 times, 52–103 times, 104–364 times, ≥365 times) as an ordinal variable.
‖The CVD mortality analyses excluded participants with a history of CVD at baseline.
¶The cancer mortality analyses excluded participants with a history of cancer at baseline.

women. In addition, the mean intensity was 6.0 metabolic equivalent of task in men and 5.6 metabolic equivalent of task in women, which represents a moderate intensity.[36] Importantly, literature has shown that physical activity is beneficial for health even when performed for bouts less than 10 minutes per session.[37] It is therefore likely that one will acquire similar health benefits from physical activity by performing sexual activity. Then, during sexual activity, there is a release of endorphins, endogenous opioid peptides that function as neurotransmitters, which generates a happy or blissful feeling.[38] This feeling may be associated with better mental health and specifically enjoyment of life. Importantly, circulating endorphin levels have been shown to be associated with higher natural killer cell activity.[38] A higher natural killer cell activity may be associated with a lower risk of cancer and viral illness; they have also been found to prevent against infections of the lungs and play an important role in improving asthma and many other conditions[39,40] and thus likely to be associated with lower levels of limiting long-standing illness and higher levels of self-rated health. Moreover, those who engage in sexual intercourse with their partner are likely to share a closer relationship,[41] and closeness to one's partner has been shown to be associated with well-being per se.[41] The association between sexual activity and physical health is complex, and the corresponding mechanisms are not completely understood. Giles et al has described that reduced ejaculatory frequency, especially in early adult life, was associated with an increased risk of prostate cancer. The authors also described a negative trend in the third decade, independent of those in the fourth or fifth.[42] Other studies have found similar findings.[43,44] Potential explanations are given by the hormone-dependency of both sexual activity, including libido and prostate cancer or the concept of prostatic carcinogenesis involving the luminal fluid, prostatic tissue interaction.[45] Finally, it is possible that early symptoms of diseases may predict a decline in sexual activity before the diagnosis of the condition. Indeed, clinically there are often no symptoms of prostate cancer even when the disease is in an advanced stage. Moreover, it is plausible to assume that onset of the disease will be associated with a reduction in sexual activity. It is likely that the discussed associations

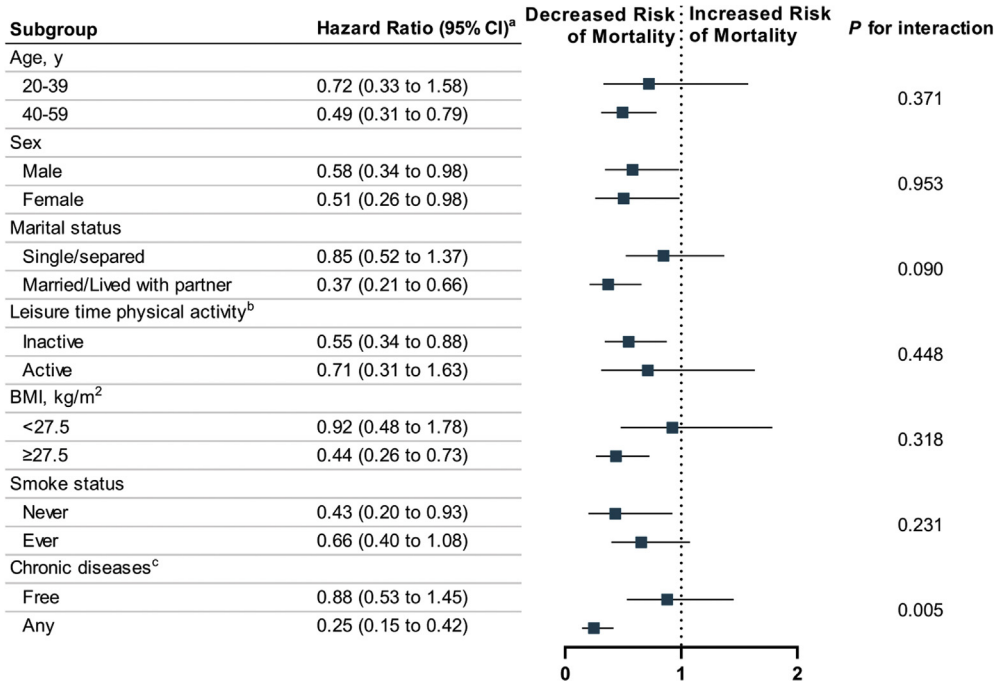

Figure 2. Stratified hazard ratios and 95% CIs for all-cause mortality according to regular sexual activity (≥2 times/y vs ≤1 time/y). [a]The sexual frequency was categorized into 0-1 time/y (reference group) vs ≥2 times/y. The models were adjusted for age, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and other), education attainment (less than high school, high school graduate, above high school), family poverty ratio (<1.30, 1.30–3.49, or ≥3.5), physical activity (active/inactive), alcohol consumption (0, 0.1–4.9, 5–14.9, 15–29.9, or ≥30 g/d), BMI, smoking status (never smoking, past <20 pack-years, past ≥20 pack-years, past without pack-year information, current < 20 pack-years, and current ≥ 20 pack-years), hypertension (yes/no), hypercholesterolemia (yes/no), diabetes (yes/no), history of CVD (yes/no), history of cancer (yes/no), and general health condition (poor, fair, good, very good, and excellent). [b]Leisure-time physical activity level was defined by engaging in no (inactive) or any (active) moderate or vigorous recreational physical activity over the past 30 days (2005-2006) or in a typical week (2007–2016). [c]Chronic diseases included cardiovascular diseases, cancer, and diabetes. Figure 2 is available in color online at www.jsm.jsexmed.org.

between decline in sexual activity and desire and the varying health outcomes result from a combination of all the discussed pathways.

Clear strengths of the present study include the large representative sample of the noninstitutionalized US population which allowed for the first time an accurate secular trend of the prevalence of sexual activity among US adults over time, as well as the identification of precise estimates in relation to sexual activity and mortality. However, findings from this study should be interpreted in light of its limitations. First, sexual activity was self-reported potentially introducing reporting bias. Indeed, people may underestimate or overestimate their level of sexual activity. Second, because of the observational nature of the study design and unmeasured confounders, causality could not be determined. The future studies need to examine the association using longer follow-up durations to verify the findings.

In conclusion, the prevalence of sexual activity was stable among US adults aged 20-59 years from 2005-2006 to 2015-2016. However, levels of sexual activity declined with increasing age. Moreover, sexual activity was found to be associated with a lower risk of all-cause mortality, CVD mortality, and cancer mortality.

ACKNOWLEDGMENT

Role of sponsor: The study sponsors have no role in the study design, collection, analysis, and interpretation of data.

Authors' contributions: C.C. and L.S. had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. C.C., L.Y., and L.S. contributed to conceptualization, framed the methodology for the study, and carried out the investigation. C.C., L.Y., TX, Q.L., and L.S. wrote the original draft. All authors eeviewed and edited the article. C.C. performed the formal analysis. C.C. and L.S. contributed to identifying the resources and supervised the study processes.

Corresponding Authors: Chao Cao, MPH, Program in Physical Therapy and Department of Medicine, Washington University School of Medicine, 4444 Forest Park Ave, St Louis, MO 63110, USA. Tel: 314-296-2895; Fax: 314-286-1400; E-mail: caochao@wustl.edu. Lee Smith, PhD, Cambridge Centre for Sport and Exercise Sciences, Anglia Ruskin University, Compass House, Cambridge, CB1 1PT, UK; E-mail: lee.smith@anglia.ac.uk

Conflict of Interests: The authors have no conflicts to disclose.

Funding: This project received no financial support.

STATEMENT OF AUTHORSHIP

Category 1

(a) Conception and Design
Chao Cao; Lin Yang; Lee Smith
(b) Acquisition of Data
Chao Cao
(c) Analysis and Interpretation of Data
Chao Cao; Lee Smith

Category 2

(a) Drafting the Article
Chao Cao; Lin Yang; Tianlin Xu; Qinran Liu; Lee Smith
(b) Revising It for Intellectual Content
Chao Cao; Lin Yang; Tianlin Xu; Patricia A. Cavazos-Rehg; Qinran Liu; Daragh McDermott; Nicola Veronese; Thomas Waldhoer; Petre Cristian Ilie; Shahrokh F. Shariat; Lee Smith

Category 3

(a) Final Approval of the Completed Article
Chao Cao; Lin Yang; Tianlin Xu; Patricia A. Cavazos-Rehg; Qinran Liu; Daragh McDermott; Nicola Veronese; Thomas Waldhoer; Petre Cristian Ilie; Shahrokh F. Shariat; Lee Smith

REFERENCES

1. World Health Organization. Sexual and reproductive health. Available at: https://www.who.int/reproductivehealth/topics/sexual_health/sh_definitions/en/. Accessed June 2, 2020.
2. Twenge JM, Sherman RA, Wells BE. Declines in Sexual Frequency among American Adults, 1989—2014. **Arch Sex Behav 2017;46:2389-2401**.
3. Herbenick D, Reece M, Schick V, et al. Sexual Behavior in the United States: Results from a National Probability Sample of Men and Women Ages 14-94. **J Sex Med 2010;7:255-265**.
4. de Martel C, Plummer M, Vignat J, et al. Worldwide burden of cancer attributable to HPV by site, country and HPV type. **Int J Cancer 2017;141:664-670**.
5. Moscicki A-B, Hills N, Shiboski S, et al. Risks for Incident Human Papillomavirus Infection and Low-Grade Squamous Intraepithelial Lesion Development in Young Females. **JAMA 2001;285:2995-3002**.
6. Sarma AV, McLaughlin JC, Wallner LP, et al. Sexual Behavior, Sexually Transmitted Diseases and Prostatitis: The Risk of Prostate Cancer in Black Men. **J Urol 2006;176:1108-1113**.
7. Perz JF, Armstrong GL, Farrington LA, et al. The contributions of hepatitis B virus and hepatitis C virus infections to cirrhosis and primary liver cancer worldwide. **J Hepatol 2006;45:529-538**.
8. Judd A, Zangerle R, Touloumi G, et al. Comparison of Kaposi Sarcoma Risk in Human Immunodeficiency Virus-Positive Adults Across 5 Continents: A Multiregional Multicohort Study. **Clin Infect Dis 2017;65:1316-1326**.
9. Freiberg MS, Chang C-CH, Skanderson M, et al. The risk of incident coronary heart disease among veterans with and without HIV and hepatitis C. **Circ Cardiovasc Qual Outcomes 2011;4:425-432**.
10. Jackson SE, Yang L, Koyanagi A, et al. Declines in Sexual Activity and Function Predict Incident Health Problems in Older Adults: Prospective Findings from the English Longitudinal Study of Ageing. **Arch Sex Behav 2020;49:929-940**.
11. Lotti F, Maggi M. Sexual dysfunction and male infertility. **Nat Rev Urol 2018;15:287-307**.
12. Lotti F, Corona G, Castellini G, et al. Semen quality impairment is associated with sexual dysfunction according to its severity. **Hum Reprod (Oxford, England) 2016;31:2668-2680**.
13. Blum K, Werner T, Carnes S, et al. Sex, drugs, and rock 'n' roll: hypothesizing common mesolimbic activation as a function of reward gene polymorphisms. **J psychoactive Drugs 2012;44:38-55**.
14. Miner M, Esposito K, Guay A, et al. Cardiometabolic Risk and Female Sexual Health: The Princeton III Summary (CME). **J Sex Med 2012;9:641-651**.
15. Friedman S. Cardiac disease, anxiety, and sexual functioning. **Am J Cardiol 2000;86:46-50**.
16. Brody S, Preut R. Vaginal Intercourse Frequency and Heart Rate Variability. **J Sex Marital Ther 2003;29:371-380**.
17. Ebrahim S, May M, Ben Shlomo Y, et al. Sexual intercourse and risk of ischaemic stroke and coronary heart disease: the Caerphilly study. **J Epidemiol Community Health 2002:56-102**.
18. Lê MG, Bacheloti A, Hill C. Characteristics of reproductive life and risk of breast cancer in a case-control study of young nulliparous women. **J Clin Epidemiol 1989;42:1227-1233**.
19. Smith L, Yang L, Veronese N, et al. Sexual Activity is Associated with Greater Enjoyment of Life in Older Adults. **Sex Med 2019;7:11-18**.
20. Flynn T-J, Gow AJ. Examining associations between sexual behaviours and quality of life in older adults. **Age and Ageing 2015;44:823-828**.
21. Jackson SE, Firth J, Veronese N, et al. Decline in sexuality and wellbeing in older adults: A population-based study. **J Affective Disord 2019;245:912-917**.
22. Smith L, Grabovac I, Yang L, et al. Sexual activity and cognitive decline in older age: a prospective cohort study. **Aging Clin Exp Res 2020;32:85-91**.
23. Wright H, Jenks RA. Sex on the brain! Associations between sexual activity and cognitive function in older age. **Age and Ageing 2016;45:313-317**.
24. Seldin DR, Friedman HS, Martin LR. Sexual activity as a predictor of life-span mortality risk. **Personal Individual Differences 2002;33:409-425**.
25. Chen H-K, Tseng C-D, Wu S-C, et al. A prospective cohort study on the effect of sexual activity, libido and widowhood on mortality among the elderly people: 14-year follow-up of 2453 elderly Taiwanese. **Int J Epidemiol 2007;36:1136-1142**.
26. Curtin LR, Mohadjer LK, Dohrmann SM, et al. The National Health and Nutrition Examination Survey: Sample Design, 1999-2006. **Vital Health Stat Ser 2, Data Eval Methods Res 2012:1-39**.
27. Yang L, Cao C, Kantor ED, et al. Trends in Sedentary Behavior Among the US Population, 2001-2016. **JAMA 2019;321:1587**.

28. Grabovac I, Cao C, Haider S, et al. Associations Among Physical Activity, Sedentary Behavior, and Weight Status With Sexuality Outcomes: Analyses from National Health and Nutrition Examination Survey. **J Sex Med 2020;17:60-68.**

29. Centers for Disease Control and Prevention. NCHS Data Linked to NDI Mortality Files. Available at: https://www.cdc.gov/nchs/data-linkage/mortality.htm. Accessed June 2, 2020.

30. Cao C, Yang L, Cade WT, et al. Cardiorespiratory Fitness Is Associated With Early Death Among Healthy Young and Middle-Aged Baby Boomers and Generation Xers. **Am J Med 2020.**

31. Cao C, Hu L, Xu T, et al. Prevalence, correlates and misperception of depression symptoms in the United States, NHANES 2015—2018. **J Affective Disord 2020;269:51-57.**

32. Grabovac I, Smith L, Stefanac S, et al. Health Care Providers' Advice on Lifestyle Modification in the US Population: Results from the NHANES 2011-2016. **Am J Med 2019;132:489-497.e1.**

33. Soysal P, Cao C, Xu T, et al. Trends and prevalence of nocturia among US adults, 2005-2016. **Int Urol Nephrol 2019;52:805-813.**

34. Lee DM, Nazroo J, O'Connor DB, et al. Sexual Health and Well-being Among Older Men and Women in England: Findings from the English Longitudinal Study of Ageing. **Arch Sex Behav 2016;45:133-144.**

35. Lindau ST, Schumm LP, Laumann EO, et al. A Study of Sexuality and Health among Older Adults in the United States. **New Engl J Med 2007;357:762-774.**

36. Frappier J, Toupin I, Levy JJ, et al. Energy expenditure during sexual activity in young healthy couples. **PloS one 2013;8:e79342.**

37. Magutah K, Meiring R, Patel NB, et al. Effect of short and long moderate-intensity exercises in modifying cardiometabolic markers in sedentary Kenyans aged 50 years and above. **BMJ Open Sport Exerc Med 2018;4:e000316.**

38. Rokade PB. Release of Endomorphin Hormone and Its Effects on Our Body and Moods : A Review. **Internationa Conf Chem Biol Environ Sci 2011;431127:436-438.**

39. Mandal A, Viswanathan C. Natural killer cells: In health and disease. **Hematology/oncology Stem Cel Ther 2015;8:47-55.**

40. Wu J, Lanier LL. Natural killer cells and cancer. **Adv Cancer Res 2003;90:127-156.**

41. Kontula O, Haavio-Mannila E. The Impact of Aging on Human Sexual Activity and Sexual Desire. **J Sex Res 2009;46:46-56.**

42. Giles GG, Severi G, English DR, et al. Sexual factors and prostate cancer. **BJU Int 2003;92:211-216.**

43. Rider JR, Wilson KM, Sinnott JA, et al. Ejaculation Frequency and Risk of Prostate Cancer: Updated Results with an Additional Decade of Follow-up. **Eur Urol 2016;70:974-982.**

44. Papa NP, MacInnis RJ, English DR, et al. Ejaculatory frequency and the risk of aggressive prostate cancer: Findings from a case-control study. **Urol Oncol 2017;35:530.e7-530.e13.**

45. Isaacs JT. Prostatic structure and function in relation to the etiology of prostatic cancer. **The Prostate 1983;4:351-366.**

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jsxm.2020.05.028.