Published in final edited form as:

Am J Cardiol. 2010 January 15; 105(2): 192–197. doi:10.1016/j.amjcard.2009.08.671.

Sexual Activity, Erectile Dysfunction, and Incident Cardiovascular Events

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Abstract

Although erectile dysfunction (ED) is considered a well-established risk factor for cardiovascular disease (CVD), few studies have investigated whether other aspects of sexual function might predict CVD independently of ED. In a longitudinal, population-based study of community-dwelling men participating in the Massachusetts Male Aging Study, we examined sexual function variables (including ED) and the subsequent development of CVD. ED was defined according to a validated, discriminant-analytic formula determined from the questionnaire responses and categorized as moderate/complete ED versus none/minimal. CVD included a wide range of major end points and was ascertained through self-report, medical records, and the National Death Index. We calculated the age-adjusted incidence rates according to the person-years of follow-up, and Cox proportional hazards models were used to estimate covariate-adjusted, Framingham risk score-adjusted, and ED-adjusted hazard ratios and 95% confidence intervals for sexual function variables and the subsequent risk of CVD. Of the 1,165 men free of CVD at baseline, the age-adjusted CVD incidence rate for moderate/complete ED and none/minimal ED was 17.9/1,000 person-years and 12.5/1,000 person-years, respectively. In multivariate models adjusted for age, covariates, ED, and the Framingham risk score, a low frequency of sexual activity (once a month or less vs ≥ 2 times weekly) was associated with increased risk of CVD (hazard ratio 1.45, 95% confidence interval 1.04 to 2.01). In conclusion, our results suggest that a low frequency of sexual activity predicts CVD independently of ED and that screening for sexual activity might be clinically useful.

Longitudinal studies have shown that erectile dysfunction (ED) is a risk factor for incident cardiovascular disease (CVD)^{1–4} and CVD mortality.⁵ However, little is known about how or whether other aspects of sexual health, in addition to ED, are associated with the development of CVD. The objective of the present analysis was to examine, in a population-based study of community-dwelling men, whether non-ED aspects of sexual function (including the frequency of sexual activity and satisfaction with sex life) are associated with the subsequent development of CVD, independently of ED status. If associated with an increased risk, these additional aspects of sexual health beyond ED might prove useful as additional risk markers or clinical screening criteria. Although past studies have considered sexual activity and intercourse frequency and subsequent CVD or stroke,^{6,7} to our knowledge, this is the first study that has considered a broad range of sexual function parameters and CVD risk.

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Methods

The Massachusetts Male Aging Study (MMAS) is a population-based, longitudinal cohort study of aging, health, and endocrine and sexual function conducted among a random sample of men observed at 3 points (T1, 1987 to 1989; T2, 1995 to 1997; and T3, 2002 to 2004). The sampling design and field protocol have been previously described.⁸ In brief, men aged 40 to 70 years old were randomly selected from 11 cities and towns near Boston, Massachusetts. Men in older age groups were oversampled to provide approximately equal proportions in each age decade (age 40 to 49, 50 to 59, and 60 to 70 years). At baseline (T1, 1987 to 1989), 1,709 men (52% of 3,258 eligible) were enrolled in the study. These response rates were expected, given the requirements for early-morning phlebotomy and extensive in-person interviews. A telephone survey of nonrespondents (n = 206) revealed that they were similar to the respondents in general health and the prevalence of chronic diseases. The MMAS subjects were observed again in 1995 to 1997 (T2, n = 1,156, 77% response rate) and 2002 to 2004 (T3, n = 853, 65% response rate). The MMAS participants were typically white (95%), employed (78%), and married (75%), and most had completed a high school education (71%). The low representation of racial minorities (5%) was similar to the racial composition of the general population of Massachusetts. Data from the 1990 US Census indicate that only 9% of men aged 40 to 69 years in Massachusetts were nonwhite.⁹ MMAS received institutional review board approval, and all participants gave written informed consent.

A trained field technician/phlebotomist visited each subject in his home. Anthropometric data on height, weight, and waist and hip circumference were obtained using standardized procedures developed for large-scale epidemiologic field studies.¹⁰ Two blood pressure measures were obtained during the interview at two time points, 25 minutes apart, and averaged. The following information was collected by interviewer-administered questionnaire: demographics, psychosocial factors, history of chronic disease, self-assessed general health status, tobacco and alcohol use, nutritional intake, a full medication inventory, a set of common complaints (e.g., headaches, backaches, trouble sleeping), and physical activity/energy expenditure during the past 7 days. Also, we constructed the Framingham risk score, which gives the 10-year estimated probability of a coronary heart disease event according to Adult Treatment Panel III Guidelines,¹¹ using age, total cholesterol, high-density lipoprotein cholesterol, blood pressure, diabetes, and smoking status.

During the in-home visit at T1, a self-administered questionnaire was used to evaluate sexual function.¹² The questionnaire included 23 items related to sexual function and had been adapted from previously validated instruments.^{13,14} It had been field-tested and was self-administered in private at the end of an hour-long interview. A validated algorithm was used to identify men with ED. In brief, the responses to questions pertaining to self-reported aspects of sexual function, including frequency of activity, quantity of erections, awakening with erections, frequency of ejaculation, attitudes about sexual decline, and sexual arousal levels compared to adolescence were used to classify men in the MMAS as having none, minimal, moderate, or complete ED. In the present analysis we classified men with ED as having moderate or complete ED.¹⁵ Sexual function variables, in addition to ED, that were considered independently in the present analysis are listed in Table 1.

The data on CVD were obtained from 3 sources: self-report, linkage of the MMAS database with the National Death Index (NDI),¹⁶ and medical records. Self-reports included a wide range of major CVD end points (i.e., myocardial infarction, stroke, coronary artery bypass graft surgery, congestive heart failure). Those who gave positive endorsement of any of these were considered to have CVD. According to the medical records and NDI (underlying cause), CVD was determined according to the *International Classification of Diseases* (ICD). Before 1999, the events/deaths were coded according to the ICD, Ninth Revision, and, subsequently,

according to the ICD, Tenth Revision. Subjects with ICD-9/ICD-10 codes 390-459/I00-I99, which include coronary heart disease, heart failure, peripheral vascular disease, cerebrovascular disease, and other vascular diseases, were considered cases of CVD.¹⁷ Of the 298 cases of CVD, 83 were obtained by self-report only, 37 were identified by NDI only, and the remaining 178 from the medical records. We also performed analyses restricting CVD cases to those whose CVD status was confirmed by medical record or NDI ($n = 215$). In that analysis, self-reported CVD cases were considered noncases, and their person-years were appropriately adjusted.

Men who reported CVD at baseline were excluded from the analyses ($n = 266$). The remaining men were required to have complete ED data at baseline ($n = 1,165$). Person-years were accumulated from each subject's baseline visit to the date of the last observation or event date. We computed the incidence rates (cases/person-years) with the 95% confidence intervals (CIs) under the assumption that such rates followed a Poisson distribution.¹⁸ The rates were internally age-adjusted to the age distribution of the analysis sample. A hazard ratio (HR) was calculated using the Cox proportional hazards regression model.¹⁹ The covariate adjustment included marital status, employment status, education, waist circumference, and self-rated overall health. For subjects with no CVD who were observed at follow-up, the status of each covariate was updated at that time. Each subject could therefore contribute ≤ 2 nonoverlapping risk intervals to the analysis. The tests for linear trend across exposure categories were performed by creating linear contrasts. Significance was considered present when $p < 0.05$. All analyses were conducted using Statistical Analysis Systems, version 9.2 (SAS Institute, Cary, North Carolina).

Results

Overall, 1,165 men were included in the present analysis, of whom 213 had ED at baseline. The men were followed up for an average of 16.2 years. Table 2 lists the baseline characteristics of the men according to ED status. The men with ED were older on average (59 ± 8 years) than the men without ED (53 ± 8 years). The men with ED had a lower household income, were more likely to have been diagnosed with hypertension or diabetes, had worse overall self-reported health, a greater prevalence of smoking, and a slightly greater body mass index. Overall, 40% of men with ED were in the greatest risk category for the Framingham risk score compared to 19% of men without ED. ED was significantly related to the age-adjusted CVD incidence rates ($p = 0.04$; Table 3). For the binary ED variable, the CVD incidence was 12.5 (95% CI 10.8 to 14.3) per 1,000 person-years among men with none/minimal ED and was 17.9 (95% CI 14.1 to 22.6) per 1,000 person-years among men with moderate/complete ED ($p = 0.03$).

Table 3 also presents the age-adjusted CVD incidence rates according to other aspects of sexual function. Satisfaction with one's sex life and sexual relationship were not related to the CVD incidence, and the findings for these 2 parameters were not consistent. Men who desired sex ≥ 2 to 3 times per week had a slightly lower rate of CVD incidence (12.8/1,000 person-years, 95% CI 11.0 to 14.9) than men who desired sex once or a few times per month (13.9/1,000 person-years, 95% CI 11.2 to 17.4) and men who desired sex once a month or less (17.8/1,000 person-years, 95% CI 12.8 to 24.9; $p = 0.06$). The frequency of sexual activity was significantly ($p = 0.007$) associated with the CVD incidence, with the CVD incidence increasing in a dose-response fashion with a decreasing frequency of sexual activity. Men who had sex 2 to 3 times per week had a lower rate (11.5/1,000 person-years, 95% CI 9.4 to 14.2) than men who had sex a few times per month (13.5/1,000 person-years, 95% CI 11.2 to 16.2) and men who had sex once a month or less (17.6/1,000 person-years, 95% CI 13.9 to 22.3).

Table 4 lists the distribution of variables for other aspects of sexual function by ED status. As might be expected, ED status was related to these variables. Men with ED were less likely to be somewhat/extremely satisfied with their sex life (44% vs 68%) and sexual relationship (55% vs 74%) than men without ED. Men with ED reported less desire for sex (only 35% wanted to have sex ≥ 2 to 3 times per week vs 73% of men without ED) and reported having sex less often per month on average (7.1 times/month vs 2.6 times/month).

Table 5 lists the adjusted estimates from the Cox proportional hazards models for the relation between the selected sexual function and activity variables and CVD incidence. We observed no relation with CVD risk in the models for the frequency of sexual desire, and the lowest category of frequency of sexual activity (monthly or less) was significantly associated with the development of CVD (compared to sex 2 to 3 times weekly), independently of the covariate and Framingham risk score adjustment. The adjusted HR for incident CVD among men who had sex once a month or less at baseline was 1.54 (95% CI 1.13 to 2.10) compared to men who had sex ≥ 2 to 3 times/week. This association persisted after additional adjustment for ED status, although it was diminished (HR 1.45, 95% CI 1.04 to 2.01), suggesting that confounding by ED status did not entirely explain this result. The findings were also consistent when the analysis was restricted to those men whose CVD information was derived from the medical records or NDI.

The significant association of satisfaction with sex life with the development of CVD adjusted for covariates and the Framingham risk score was attenuated (but was close to statistical significance) after additional adjustment for ED status (HR 1.27, 95% CI 0.97 to 1.67) but was diminished further in models that considered only non-self-reported CVD outcomes (HR 1.05, 95% CI 0.75 to 1.47). Considering satisfaction with one's sexual relationship, the HR for this variable increased in magnitude and the relation became statistically significant when the CVD end point included only men whose CVD status was determined from the medical record or NDI. Men who reported dissatisfaction with their sexual relationship were less likely to develop CVD than were men who reported they were satisfied (HR adjusted for covariates, Framingham risk score, and ED 0.56, 95% CI 0.33 to 0.93; $p = 0.03$).

Discussion

In our population-based study of community-dwelling men, we have previously reported an association of ED with CVD mortality⁵ and CVD incidence.²⁰ The present findings extend this work by showing that, in addition to ED, another aspect of sexual function (the frequency of sexual activity) was an independent risk factor for CVD. We propose several possible explanations for these findings. The frequency of sexual activity (in our data, this could include intercourse or other activity) is a variable that might include libido, erectile function, and the capacity for physical activity. As such, persons with the desire for, and who are able to engage in, frequent sexual activity are likely to be healthier in ways not necessarily captured by our data. However, rather than simply serving as a proxy measure of overall health, sexual activity in some forms has a physical activity component that might directly serve to protect cardiovascular health. Third, the frequency of activity might also serve as an additional marker of ED disease severity beyond what is captured in our ED measure. Finally, men who have frequent sexual activity might be more likely to be in a supportive intimate relationship with a regular partner; this might also improve cardiovascular health through stress reduction and social support. A proxy for a supportive relationship with a regular partner, marital status, was included in the models but did not explain our findings.

Our findings for satisfaction with one's sexual relationship were in the opposite direction to another variable, satisfaction with sex life, in that men who reported dissatisfaction with their sexual relationship were less likely to develop CVD in some models. Men who reported that

they were dissatisfied with their sexual relationship tended to be younger, leaner, healthier, and less likely to be in the greatest category of the Framingham risk score than men who were dissatisfied with their sex life (data not shown). As such, unmeasured confounding associated with age-related factors could be driving the association of sexual relationship and CVD. We are unaware of a known aspect of relationship dissatisfaction that would contribute directly to reduced CVD risk.

The MMAS population was representative of the racial groups in Massachusetts at the time of sampling⁹; however, as primarily a white, high socioeconomic status population, our new results are not immediately generalizable to men living in other parts of the United States, to men of lower socioeconomic status, or to racial or ethnic minorities not well represented in Massachusetts. The measurement of ED at baseline used an internal algorithm and was not based on the measurement scales commonly used today in the assessment of ED, such as the International Index of Erectile Function.²¹ However, we examined the construct validity of the method and found it to be internally valid.¹⁵ The strengths of our study included its longitudinal design, the ability to examine outcomes not based only on self-report, the inclusion of co-morbidities, and psychosocial data. Despite our use of the Framingham risk score, we did not have all established CVD risk factors (e.g., family history of CVD). Our findings should be reproduced in other longitudinal studies that also measure ED. If replicated, our results could have clinical implications, in that the measurement of the frequency of sexual activity, in addition to the determination of ED, might be a useful tool in screening for cardiovascular risk.

Acknowledgments

The Massachusetts Male Aging Study was supported by grant AG04763 from the National Institute on Aging and grants DK51345 and DK44995 from the National Institute of Diabetes and Digestive and Kidney Diseases (Bethesda, MD). Additional support for these analyses was provided by Eli Lilly and Company (Indianapolis, IN).

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Table 1

Sexual function questions (abbreviated) from Massachusetts Male Aging Study (baseline data) used in present analysis

Question
How satisfied are you with your sex life?
How satisfied are you with your sexual relationship with your present partner or partners?
How satisfied do you think your partner(s) is (are) with your sexual relationship?
Has the frequency of your sexual activity with a partner been (as much as you desire/less than you desire/more than you desire)?
How frequently do you feel sexual desire?
In an average week, how frequently do you usually have sexual intercourse or activity?
Compared with when you were an adolescent (around 18–20 years) do you feel sexually aroused? (more than, about the same, less than)

Table 2

Descriptive characteristics of analytic sample by baseline erectile dysfunction (ED) status

Variable	Subjects Without ED (n = 952)	Subjects With ED (n = 213)
Age (years)	53.8 ± 8	59.8 ± 8
Marital status		
Never married	87 (9%)	21 (10%)
Currently married	736 (77%)	158 (74%)
Divorced/separated	107 (11%)	26 (12%)
Widowed	22 (2%)	8 (4%)
Education		
High school or less	212 (22%)	83 (39%)
Some college or bachelor's degree	398 (42%)	85 (40%)
Advanced study bachelor's degree	342 (36%)	45 (21%)
Annual household income		
<\$40,000	295 (32%)	102 (50%)
\$40,000–\$79,999	414 (44%)	74 (36%)
≥\$80,000	225 (24%)	29 (14%)
Hypertension	244 (26%)	71 (33%)
Diabetes mellitus	50 (5%)	22 (10%)
Self-assessed health		
Excellent	354 (37%)	45 (21%)
Very good	363 (38%)	77 (36%)
Good	192 (20%)	75 (35%)
Fair/poor	41 (4%)	16 (8%)
Current smoker	217 (23%)	56 (26%)
Body mass index (kg/m ²)	27.0 ± 4.24	27.5 ± 4.47
Waist circumference (in.)	38.0 ± 4.37	38.9 ± 4.81
Framingham risk score category (%)		
<5	163 (17%)	14 (7%)
5–10	293 (31%)	51 (24%)
10–20	316 (33%)	63 (30%)
>20	180 (19%)	85 (40%)

Data are presented as mean ± SD or numbers (%).

ED = erectile dysfunction.

Table 3

Age-adjusted cardiovascular disease incidence rates and 95% confidence intervals (95% CIs) according to sexual function

Variable	Events (n)	Person-Years (n)	Age-Adjusted IR/1,000 Person-Years	95% CI	p Value*
All subjects	298	18,886	13.3	11.7–15.1	<0.001
Erectile dysfunction					0.04
None	145	10,535	13.0	11.0–15.2	
Minimal	61	4,609	11.4	8.9–14.5	
Moderate	34	1,597	16.6	11.9–23.2	
Complete	58	2,145	18.6	13.8–25.0	
Erectile dysfunction group					0.03
None/minimal	206	15,144	12.5	10.8–14.3	
Moderate/complete	92	3,742	17.9	14.1–22.6	
How satisfied are you with your sex life?					0.09
Somewhat/extremely satisfied	163	11,261	12.4	10.6–14.5	
Neither satisfied nor dissatisfied	50	3,059	13.4	10.1–17.7	
Somewhat/extremely dissatisfied	82	4,468	15.5	12.4–19.4	
How satisfied are you with your sexual relationship?					0.08
Somewhat/extremely satisfied	167	11,310	13.0	11.1–15.2	
Neither satisfied nor dissatisfied	51	2,380	18.0	13.7–23.5	
Somewhat/extremely dissatisfied	31	2,820	9.3	6.5–13.2	
Frequency of sexual desire?					0.06
≥2–3 times/week	159	12,024	12.8	11.0–14.9	
Once a week or 2–3 times/month	95	5,258	13.9	11.2–17.4	
Once a month or less	44	1,575	17.8	12.8–24.9	
Frequency of sexual activity (obtained from continuous variable)					0.007
≥2–3 times/week	86	7,311	11.5	9.4–14.2	
Once a week or 2–3 times/month	116	7,408	13.5	11.2–16.2	
Once a month or less	90	3,843	17.6	13.9–22.3	

*Trend test for ordinal variables.

IR = incidence rate.

Table 4

Relation between erectile dysfunction (ED) and other aspects of sexual function

Variable	Subjects Without ED (n = 952)	Subjects With ED (n = 213)
How satisfied are you with your sex life?		
Somewhat/extremely satisfied	641 (68%)	91 (44%)
Neither satisfied nor dissatisfied	126 (13%)	46 (22%)
Somewhat/extremely dissatisfied	180 (19%)	71 (34%)
How satisfied are you with your sexual relationship?*		
Somewhat/extremely satisfied	621 (74%)	73 (55%)
Neither satisfied nor dissatisfied	127 (15%)	33 (25%)
Somewhat/extremely dissatisfied	95 (11%)	26 (20%)
Frequency of sexual desire?		
≥2–3 times/week	690 (73%)	75 (35%)
Once a month or 2–3 times/month	229 (24%)	72 (34%)
Once a month or less	30 (3%)	65 (31%)
Frequency of sexual activity (per month)	7.1 ± 6.5	2.6 ± 3.8
Frequency of sexual activity (obtained from continuous variable)		
≥2–3 times/week	451 (48%)	25 (13%)
Once a week or 2–3 times/month	376 (40%)	67 (35%)
Once a month or less	114 (12%)	100 (52%)

Data are presented as numbers (%) or mean ± SD.

* Data are missing due to skip pattern, because question was not asked of men who reported no sexual partner.

ED = erectile dysfunction.

Table 5

Multivariate Cox proportional hazards modeling estimates and 95% confidence intervals (CIs) for sexual function at baseline and incident cardiovascular disease

Model	Cardiovascular Disease			
	Measured by Self-Report, Medical Record, or NDI		Measured by Medical Record or NDI	
	HR (95% CI)	p Value	HR (95% CI)	p Value
Frequency of sexual desire				
Framingham and covariate adjusted*				
Weekly or 2–3 times monthly vs ≥2–3 times weekly	1.05 (0.80–1.37)	0.72	0.88 (0.63–1.22)	0.43
Monthly or less vs ≥2–3 times weekly	1.20 (0.84–1.73)	0.32	1.29 (0.85–1.94)	0.23
Framingham, covariate, and erectile dysfunction adjusted†				
Weekly or 2–3 times monthly vs 2–3 times weekly	1.00 (0.76–1.31)	0.99	0.82 (0.59–1.15)	0.25
Monthly or less vs ≥2–3 times weekly	1.04 (0.70–1.55)	0.84	1.08 (0.68–1.70)	0.75
Frequency of sexual activity				
Framingham and covariate adjusted*				
Weekly or 2–3 times monthly vs ≥2–3 times weekly	1.12 (0.84–1.49)	0.44	1.01 (0.72–1.42)	0.95
Monthly or less vs ≥2–3 times weekly	1.54 (1.13–2.10 [‡])	0.007	1.54 (1.07–2.22 [‡])	0.02
Framingham, covariate, and erectile dysfunction adjusted†				
Weekly or 2–3 times monthly vs ≥2–3 times weekly	1.10 (0.83–1.46)	0.52	0.99 (0.70–1.40)	0.97
Monthly or less vs ≥2–3 times weekly	1.45 (1.04–2.0 [‡])	0.03	1.43 (0.97–2.11)	0.07
Satisfied with sex life?				
Framingham and covariate adjusted*				
Neutral vs satisfied	0.95 (0.69–1.32)	0.76	0.95 (0.65–1.39)	0.79
Dissatisfied vs satisfied	1.33 (1.02–1.74 [‡])	0.04	1.12 (0.81–1.56)	0.48
Framingham, covariate, and erectile dysfunction adjusted†				
Neutral vs satisfied	0.93 (0.67–1.29)	0.68	0.92 (0.63–1.35)	0.68
Dissatisfied vs satisfied	1.27 (0.97–1.67)	0.09	1.05 (0.75–1.47)	0.76
Satisfied with sexual relationship?				
Framingham and covariate adjusted*				
Neutral vs satisfied	1.04 (0.75–1.45)	0.79	0.87 (0.58–1.30)	0.50
Dissatisfied vs satisfied	0.76 (0.51–1.14)	0.18	0.60 (0.36–0.99 [‡])	0.05

Model	Cardiovascular Disease			
	Measured by Self-Report, Medical Record, or NDI		Measured by Medical Record or NDI	
	HR (95% CI)	p Value	HR (95% CI)	p Value
Framingham, covariate, and erectile dysfunction adjusted [†]				
Neutral vs satisfied	1.02 (0.73–1.41)	0.92	0.85 (0.57–1.26)	0.41
Dissatisfied vs satisfied	0.73 (0.49–1.09)	0.12	0.56 (0.33–0.93 [‡])	0.03

* Covariates were marital status, employment status, education, waist circumference, and self-rated overall health.

[†] Models were adjusted for all the above, the Framingham risk score (continuous), and ED.

[‡] Estimates with 95% CIs that excluded 1.00.