Are Sex Hormones Biomarkers of Health or Sexual Function in Later Life?

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Abstract

The relationship between sex hormone physiology and sexual function in older men and women is complex and, based primarily on small clinical or laboratory studies, only partially understood. Data from the National Social Life, Health and Aging Project (NSHAP), including salivary sex hormone measures, were used to explore the associations between endogenous sex hormone levels with global self-reported health and characteristics of sexual performance. In multivariate analyses, sex hormone concentrations were differently associated with physical and sexual health. In men, high androgen concentrations were positively associated with self-reported health but high testosterone levels were associated with erectile problems, anxiety about sexual performance and complex sexual morbidity (3 or more concurrent sexual problems). Women with high estrogen levels were less likely to report excellent health but were also less likely to report sexual problems. The study revealed that the levels of the four dominant sex hormones are highly inter-correlated and sheds new light on the possible role of progesterone in later life sexuality.

Introduction

The relationship between sex hormone physiology and sexual function in older men and women is complex and, based primarily on small clinical or laboratory studies, only partially understood (Basson 2007). Estrogen and progesterone production in women decline markedly with menopause and remain depressed throughout the latter half of the life span. Estrogen affects female sexual function via local effects in the genital tract and central effects in the brain (Meston and Frohlich 2000). Progesterone may play a role in sexual function and desire and has been identified to have sedative or stress-counteracting effects (Wirth and Schultheiss 2006; Wirth, Meier et al. 2007). Testosterone is the defining male sex hormone, is more abundant in men than women, but appears to play an important physiological role in sexual functioning of both. Testosterone administration may improve mood and well-being in both sexes, especially among men (Ellison et al., 2002; Grinspoon et al., 2000; Jassal et al., 1995). Circulating testosterone in women is a strong correlate of ovarian function and androgen production, though approximately one-third of circulating levels are derived via precursors from the adrenal gland (Lobo, 2001).Testosterone and DHEA production in naturally menopausal women decline gradually with age but appear to play an ongoing role in sexual libido, arousal, genital sensation, orgasm as well as mood and general sense of well-being (Santoro, Torrens et al. 2005; Booth, Granger et al. 2006).

Estrogen metabolism and synthesis in men appear to remain relatively stable across the life course (J. M. Kaufman & Vermeulen, 2005). In contrast, major changes in sex hormone metabolism occur in women around natural menopause, most notably due to a decline in ovarian estrogen production (Manly et al., 2000). Although the human life span is increasing, the mean age of menopause has not significantly changed; women are therefore living more years in a menopausal state. Relative estrogen depletion in women in later life has been

associated with a variety of age-related changes in physical and cognitive function as well as disease. Among men and women, serum estradiol concentration has been associated with bone turnover and risk of osteoporotic fractures (lower estrogen is associated with skeletal vulnerability) (Kuchuk et al., 2007). Likewise, estradiol concentration has been associated with cognition (M. C. Carlson et al., 2001; Maki & Resnick, 2000; Tivis et al., 2005), mood, and memory (Tivis et al., 2005) in women and, in combination with testosterone levels and other factors, with preservation of memory and cognitive function in men (Barrett-Connor et al., 1999; L. E. Carlson & Sherwin, 2000). A number of studies have linked higher levels of serum estradiol to increased risk for developing breast cancer (Chlebowski et al., 2003; Clemons & Goss, 2001; Tivis et al., 2005) and coronary problems (Chlebowski et al., 2003; Clemons & Goss, 2001; Manson et al., 2003; Tivis et al., 2005) in women. Much less is known about the role of estrogen in social functioning in general, or in later life.
Estrogen depletion in menopause and sustained, low levels of circulating estrogen throughout the post-menopausal lifespan significantly affect condition and function of the female genital tract.

Inquiry about the correlates and effects of sex hormones on women' sexual and mating behavior has predominantly involved younger women (little is known beyond menopausal ages). Estrogens have been shown to relate both to attractiveness (Roberts, Havlicek et al. 2004) and sexual interest (Laeng and Falkenberg 2007) among women of reproductive age. Higher levels of testosterone in women have been associated with lower interest in marrying and having children (Udry, Morris et al. 1995), and with sexual activity among teens (Udry, Morris et al. 1995; Booth, Granger et al. 2006). Testosterone, primarily in studies of men, has also been linked to social status, dominance behavior, aggression risk behavior and initiative (Booth, Granger et al. 2006). The role of another important androgen, dehydroepiandrosterone (DHEA), and progesterone in sexual behavior and function is poorly understood.

Few population-based studies have been designed to explore the relationship between endogenous sex hormones and sexuality. One Australian study (1423 women ages 18-75) found that low sexual desire, arousal, and responsiveness in younger women and sexual responsiveness in older women are associated with low serum dehydroepiandrosterone sulfate (DHEAS) (Davis, Davison et al. 2005), but not testosterone, levels. In contrast, data from the Study of Women's Health Across the Nation (SWAN) indicate that testosterone, but not DHEAS, levels are moderately associated with increased sexual desire in women ages 42-52 years (Santoro, Torrens et al. 2005). Although low estrogen associated with menopause is widely understood to negatively affect the physical condition of the female genital tract, very little is known about the relationship between sex hormones and sexual behavior or other aspects of function among older post-menopausal women.

This study aims to explore, using a probability sample of the older U.S. female population, the validity of salivary sex hormone measures in a population-based study of older women and men, and the relationship between sex hormone levels (estradiol, progesterone, testosterone and DHEA) and sexuality in later life. We also explore the degree to which sex hormone levels explain the previously observed positive association between sexuality and health among older women. This preliminary study is undertaken with the acknowledgement that sexuality is a uniquely biopsychosocial phenomenon. Although the focus is on sex hormonal correlates of later life sexual behavior and function, these factors are believed to affect sexuality through complex interactions with one another, with other physiologic systems, and in the context of important psychosocial and cultural factors.

METHODS

Study Sample

The 2005-2006 wave of NSHAP provides a nationally-representative probability sample of community-dwelling individuals ages 57 to 85, generated from households across the U.S. screened in 2004. African-Americans, Latinos, men, and the oldest-old (75 to 84 years at the time of screening in 2004) were over-sampled. In-home interviews and biomeasure collection were conducted in English and Spanish by professional interviewers, yielding 3,005 respondents and a 75.5% weighted (74.8% unweighted) response rate. Sampling weights account for differential probabilities of selection and differential non-response. Details on the design, field procedures, and sampling weights have been previously described (Lindau, Schumm et al. 2007). Analyses relating sex hormones to sexual function and problems use the subsample of men and women with a sexual partner and with salivary sex hormone data.

NSHAP dataset is available to researchers via the National Archive of Computerized Data on Aging collection: http://www.icpsr.umich.edu/NACDA/.

Saliva Specimen Collection, Processing and Hormone Assays

Sex hormonal evaluation in the clinical setting is typically performed on a serum or plasma specimen (Kaufman and Vermeulen 2005; Ziemann 2007) and can provide information about total and free circulating sex hormones. Salivary measures offer a relatively convenient and minimally-invasive approach for obtaining sex hormone data (Worthman, Stallings et al. 1990; Kaufman and Lamster 2002; Granger, Shirtcliff et al. 2004) - an advantage when working with older, infirmed, and/or population-based health study participants. Salivary sex hormone assays approximate measures of free circulating sex hormones in the blood.

All participants were asked to provide a 2 ml salivary specimen via passive drool into a small plastic tube. The tube was delivered on ice to Salimetrics, LLC (State College, PA) where endocrinologic assays were performed. Details of the salivary assays collected in the NSHAP study have been previously described (Mendoza, Curran et al. 2007; Mendoza, Curran et al. 2007; Mendoza, Curran et al. 2007; Nallanathan, Mendoza et al. 2007). Assays were conducted in duplicate on each specimen in the following priority order: 1) estrogen, 2) progesterone, 3) DHEA, 4) testosterone.

In the NSHAP public use dataset, hormone values are reported in pg/ml, which reflects the concentration of hormone per milliliter of saliva, measured in picograms. Details about the assays and coding have been previously described (Gavrilova and Lindau 2009). Each assay was conducted twice, generating two values for each sex hormone assay conducted on each participant's salivary specimen. The mean value for the two measures was generated and used in these analyses. In cases where only one valid value was obtained, it was used. Values flagged due to assay interference, insufficient volume or other factors were excluded. Distributions of sex hormones were divided into tertiles, corresponding to low, medium and high hormone levels (similar to the approaches of (Dorgan, Stanczyk et al. 1997; Tworoger, Missmer et al. 2006). Outliers were not excluded (see, for comparison, Goldman and Glei 2007).

Self-collected saliva specimens were provided by 2,722 (90.6%, unweighted) individuals. Table 1 shows the associations of individual sociodemographic and health characteristics with the likelihood of participation in the saliva collection. African Americans were significantly less likely to participate in saliva collection than individuals of other racial groups. No differences in participation with the saliva protocol were found by other sociodemographic characteristics.

Of 2,722 respondents who agreed to provide a saliva sample, 82 (3.0%) specimens were inadequate (mainly due to inability to produce a sufficient amount of saliva). In the process of

saliva collection and transportation, freezing was compromised for 20 samples. These were included in the hormone measurement protocol; inadequate freezing of these samples is flagged in the public use data set.

Salivary sex hormone measures collected in the homes of a probability sample of 1550 women ages 57-85 exhibit internal validity and align with findings from the few comparable prior studies (Gavrilova and Lindau 2009).

Other Variables Used in the Analysis

Demographic characteristics

Data are presented for three age strata, to correspond with the age structure of the NSHAP sample design: 57-64 years, 65-74 years, and 75-85 years. Gender was assessed by field staff observation. Marital status categories included married, divorced, separated, widowed, or never married. Race and ethnicity were self-reported and categorized as White, African-American, Latino, and other. Education level was dichotomized as "high school and below" and "some college and higher."

Self-rated health

Respondents were asked to rate their physical health using the standard 5-point scale with responses "excellent," "very good," "good," "fair," or "poor." In this analysis, we used three self-rated health categories: "very good/excellent," "good," and "fair/poor."

Sexuality

Sexual function was measured via self-report in face-to-face interviews with field staff. Sexuality questions were designed for comparability to the 1992 National Health and Social Life Survey and consistent with DSM IV-TR criteria and established clinical instruments for assessing female sexual dysfunction (American Psychiatric Association 2000).

Current sexual activity was defined as ever having sex with a partner in the prior 12 months. Sexual function was measured by response to the following questions: (1) How physically pleasurable did/do you find your relationship with [partner]?" Responses "very or extremely pleasurable" were considered as positive. (2) "In the last 12 months, how often did you have a sensation of pulsating or tingling in your vagina/genital area during sexual activity with [partner]?" Responses "usually or always" were considered as positive.

Sexually active respondents were asked about the presence of several sexual problems involving interest, arousal, orgasm, pain, and satisfaction, selected based on diagnostic (American Psychiatric Association 2000) and clinical criteria (Basson, Althof et al. 2004; Lue, Giuliano et al. 2004; Lue, Guiliano et al. 2004) for sexual dysfunction. Seven domains of sexual function in women were measured using positive answers to the question: whether during the last 12 months there has ever been period of several months or more when you (1) lacked interest in having sex?; (2) were unable to climax (experience an orgasm)?; (3) came to a climax too quickly; (4) experienced physical pain during intercourse?; (5) did not find sex pleasurable (even if it was not painful)?; (6) felt anxious just before having sex about performance; (7) had trouble lubricating. Indication of a concurrent problem in three or more of these seven domains constituted "complex sexual morbidity" (Lindau, Gavrilova et al. 2007). In men, seven domains of sexual function were measured using questions 1-6 (above) and an additional question: "whether during the last 12 months there has ever been period of several months or more when you had difficulty achieving and maintaining erection?" These items measured the presence of a problem for "several months or more" over the past 12 months, capturing chronic rather than episodic problems. (Lindau, Schumm et al. 2007).

Statistical Analysis

Logistic regression (Hosmer and Lemeshow 1989) was used to model the likelihood of participating in the salivary specimen collection. This model included age group (57-64, 65-74, and 75-85), race (white, African American, Hispanic/non-black and other), education (high school and below, some college and higher), self-rated health (excellent/very good, good, and fair/poor) and smoking status (current smoker, others) as covariates.

To evaluate the relationship between sexuality and health, we conducted a set of logistic regression models where self-rated health, sexual activity, sexual problems, and sexual function were used as outcome variables. Concentrations of each of the four sex hormones (log transformed) were used as explanatory variables. Age, race/ethnicity, education, self-reported health (in sexuality models), and smoking status were used as covariates in all models.

All analyses were performed using the Stata statistical software package, release 9 (StataCorp 2005). Results are presented as odds ratios together with 95% confidence intervals. To account for the unequal probabilities of selection, we performed weighted analyses using the probability weights with a post-stratification adjustment based on age and urbanicity. Inference was conducted using design-based variance estimates, obtained via the linearization method (Binder 1983) as implemented in Stata (StataCorp 2005). All p-values reported are two-sided. Correlations between saliva hormone levels were calculated using Pearson correlation coefficients of the four log-transformed hormones with each other.

RESULTS

The distribution of key demographic characteristics in the NSHAP cohort closely match those from the 2002 Current Population Surveys, (Lindau, Schumm, 2007). Men were more likely to be married than women; women were more likely to be widowed (Table 1). The distribution of self-rated health was similar for men and women. The overall prevalence of partnership (including all age groups) was 79.9% (95% CI 77.6-82.1) for men and 57.8% (95% CI 55.0-60.6) for women and declined across age groups. Only 38.5% of women versus 72.0% of men ages 75-85 were partnered. The overall proportion of respondents engaged in sexual activity was 65.7% [95% CI 19.4-61.8] for men and 42.3% [95% CI 38.0-44.4] for women. The proportion of sexually active respondents among those with a partner was significantly higher: 76.2% [95% CI 73.3-79.1] for men and 67.5% [95% CI 63.7-71.2] for women.

Mean and median values of sex hormone measurements, stratified by gender, are presented in Table 2.

Table 2 About Here

Older men demonstrate higher levels of testosterone than older women. The mean testosterone level for men (99.5 pg/ml) is about twice that of women (46.3 pg/ml). The mean salivary estradiol levels are nearly equivalent for men and women.

Sex hormones were highly correlated with each other in both men and women. The strongest correlations are observed between DHEA and testosterone. Table 3 shows the adjusted Pearson correlation coefficients of the four log-transformed hormones with each other.

Table 3 About Here

In multivariate analyses, sex hormone concentrations were differently associated with physical and sexual health (Table 4).

Table 4 About Here

In men, high combined androgen concentrations (testosterone plus DHEA) were positively associated with self-reported health. However, high testosterone levels were associated with erectile problems, anxiety about sexual performance and complex sexual morbidity. Women with high estrogen levels were less likely to report excellent health but were also less likely to report sexual problems.

Prevalence of seven sexual problems among women varied from 8.4% (climaxing too quickly) to 42.9% (lack of interest in sex). Difficulty lubricating, one of the most common sexual problems experienced by older women (39.0% of sexually active women) was not significantly associated with salivary concentrations of estradiol. However, the prevalence of complex sexual morbidity (29.4%) showed a statistically significant negative association with salivary estradiol. Anxiety about performance and climaxing too quickly among women were positively associated with salivary progesterone concentration. Among men, those with higher levels of progesterone were less likely to report lack of sexual interest and anxiety about performance.

Excluding cases of those respondents who use hormone replacement therapy or drugs affecting hormone levels (158 women and 39 men) did not change the results of this study.

DISCUSSION

The NSHAP study provides the first data on salivary sex hormone concentrations in a national, population-based sample of older community residing adults in the US. Use of minimally invasive methods for collection of sex hormonal data is feasible and provides information relevant to furthering an understanding of the role of sex hormones in relation to sexuality in later life. Population data complement clinical data by providing normative information.

Associations of sex hormone levels with the measures of sexuality found in this study are complex and are only preliminarily interpreted here.

Estrogen depletion in menopause and sustained, low levels of circulating estrogen throughout the post-menopausal lifespan significantly affect condition and function of the female genital tract. Estrogen is important for maintaining skin, subcutaneous, mucosal (vaginal, bladder, and rectal) and musculoskeletal integrity, the vaginal microenvironment (pH balance and micro-flora), vascular flow to the vagina and clitoris, and sensory perception. Over time, in the genital tract, low estrogen results in vaginal dryness, loss of epithelial cell glycogen, shortening of the vagina, narrowing of the introitus, thinning of the labia, and diminution of the fat pad underlying the mons pubis. Though the role of estrogen in female sexuality is not fully understood, it has been suggested to influence sexual desire (Dennerstein, Gotts et al. 1994; Meston and Frohlich 2000). Estrogen replacement therapy may indirectly enhance female sexual performance, by restoring vaginal lubrication (Meston and Frohlich 2000) and promoting positive body image and an overall positive sense of well-being (Bachmann and Leiblum 2004). Estrogen production in women declines markedly with menopause and remains depressed throughout the latter half of the life span. Estrogen affects female sexual function via local effects in the genital tract and central effects in the brain. This may explain the negative correlation between low estradiol concentrations and presence of complex sexual problems in women. Vaginal cytological data were obtained in NSHAP to quantify the activity of estrogen at

the level of the vaginal mucosa and will be very useful in further understanding these findings (coding of these is still underway).

Difficulty lubricating, one of the most common sexual problems experienced by older women, was not associated with salivary concentrations of estradiol. However, women with higher estradiol levels were less likely to report complex sexual morbidity and engaged in a higher frequency of sexual activity. This suggests that the subjective experience of difficulty lubricating may be different from the clinical symptom of vaginal dryness, the gold-standard treatment for which is estrogen therapy. In one study, low estrogen was found to be associated with the clinical diagnosis of vaginal atrophy, but not to complaints of vaginal dryness and dyspareunia (Laan and vanLunsen 1997).

Testosterone is the defining male sex hormone, is more abundant in men than women, but appears to play an important physiological role in sexual functioning of both. Testosterone is synthesized in the male testes, the female ovaries, and the adrenal glands in both sexes (Guyton 1991; Davis and Tran 2001). During the aging process, testosterone levels gradually decline in both sexes (Tenover 1997; Davis and Tran 2001; Lobo 2001; Ellison, Bribiescas et al. 2002; Feldman, Longcope et al. 2002; Araujo, O'Donnell et al. 2004; Kaufman and Vermeulen 2005). Testosterone administration may improve mood and well-being in both sexes, especially among men (Jassal, Barrett-Connor et al. 1995; Grinspoon, Corcoran et al. 2000; Ellison, Bribiescas et al. 2002). We found that higher levels of testosterone are associated with reporting more, rather than fewer, sexual problems in men (Table 4). Low testosterone has been related to erectile dysfunction (Yassin and Saad 2008) and testosterone replacement therapy is offered as a remedy for this problem in hypogonadal men (Chiang, Hwang et al. 2007; Blute, Hakimian et al. 2009). Other studies show no association between testosterone levels and erectile dysfunction (Rhoden, Teloken et al. 2002; Yeap 2009) or a negative association (Isidori, Giannetta et al. 2005; Yeap 2009). Data from the Massachusetts Male Aging Study demonstrated that negative correlation between testosterone levels and erectile dysfunction existed only among men with high luteinizing hormone levels (Kupelian, Shabsigh et al. 2006). We found that high levels of androgens (DHEA and testosterone) are associated with better self-rated health among men, which is consistent with prior reports about associations of higher testosterone and DHEA levels with lower mortality (Laughlin, Barrett-Connor et al. 2008), cardiovascular problems (Alexandersen, Haarbo et al. 1996) and better cognition (Barrett-Connor, Goodman-Gruen et al. 1999). In our study the positive association between testosterone levels and reports of erectile dysfunction is observed after controlling for self-rated health. It is possible that sexually active older men with higher testosterone levels are more likely than others to report sexual problems. However, more research is needed to test this hypothesis.

Testosterone, along with dehydroepiandrosterone (DHEA), may play an important role in female libido, arousal, genital sensation, and orgasm. Circulating testosterone in women is a strong correlate of ovarian function and androgen production, though approximately one-third of circulating levels are derived via precursors from the adrenal gland (Lobo 2001). Loss of testosterone can exacerbate vaginal mucosal atrophy, thinning of pubic hair, and may compromise an older woman's sense of general well-being. The relationship between female sexual interest in later life and testosterone levels is controversial (Dennerstein, Smith et al. 1994; Davis and Tran 2001). Although not found in our study, low levels of testosterone have been correlated with lower coital frequency and loss of sexual desire in men and women (Davis and Tran 2001). Two large recent population-based studies analyzed associations between

serum testosterone levels and sexuality among women (Davis, Davison et al. 2005; Santoro, Torrens et al. 2005). A community-based, cross-sectional study of 1423 women ages 18 to 75 years in Victoria, Australia failed to find an association between circulating testosterone and androstenedione levels and scores on the Profile of Female Sexual Function (PFSF) (Davis, Davison et al. 2005). Low sexual responsiveness for women ages 45 years and older was associated with having a serum DHEA level below the 10th percentile for this age (Davis, Davison et al. 2005). The US Study of Women's Health Across the Nation (SWAN), based on an ethnically diverse cohort of 2961 peri-menopausal women, explored the association of DHEA and testosterone with self-reported desire to engage in sex and frequency of arousal during sex (Santoro, Torrens et al. 2005). Testosterone concentration was associated with increased sexual desire (OR=1.09; 95% CI 1.00-1.18) and DHEA was associated modestly with functional status and self-reported health (Santoro, Torrens et al. 2005). Use of serum, versus free salivary measures, differences in the instruments used to assess sexual function, and differences in the age groups studied limit comparison of these findings to NSHAP. Lack of comparability across studies is a pervasive problem with research attempting to investigate the relationship between sex hormones and sexual behavior.

DHEA production and concentration decline significantly and steadily during human aging (Ravaglia, Forti et al. 1996; Speroff, Glass et al. 1999; Hackbert and Heiman 2002; Villareal and Holloszy 2004) in both men and women (Panjari and Davis 2007); DHEA has been suggested as a putative biomarker of physiologic aging (Johnson, Bebb et al. 2002). We did not find statistically significant associations between endogenous DHEA and sexuality measures, despite reports that DHEA supplementation may increase women's libido and sexual satisfaction (Spark 2002).

Of all the sex hormones, the role of progesterone in sexual behavior or function is least understood. Due to decline in ovarian production, progesterone production is markedly decreased following menopause. This decline may result in diminished sexual function and desire (Dennerstein, Alexander et al. 2003). Increased levels of progesterone have been found in states of stress and anxiety in men and women; this may relate to its sedative or stress-counteracting effects (Wirth and Schultheiss 2006; Wirth, Meier et al. 2007). Exogenous progesterone is used in older women primarily in combination with estrogen therapy to protect against estrogen's growth-promoting effects on the uterine endometrial lining and to treat pathological processes of the uterine endometrium. Here, we find that salivary progesterone was significantly positively associated with anxiety about sex and the relatively rare female complaint of climaxing too quickly. This latter finding is particularly interesting for two reasons. First, the prevalence of climaxing too quickly among women in NSHAP is similar to that found for younger women surveyed by Laumann and colleagues' National Health and Social Life Survey (ages 18-59, 1992), yet few other studies have queried women about this experience. Qualitative work may be needed to understand what women mean in response to this item. Clinical experience corroborates that some women do feel that they experience orgasm quicker than desired due to hypersensitivity of the clitoris. Other women are bothered by climaxing in advance of their partner. Why progesterone concentrations, in particular, might relate to this experience in older women is a matter for deeper exploration and will benefit from external validation. Effects of progesterone on male sexuality are poorly understood and most of the literature derives from animal research (Andersen and Tufik 2006).

This study provides an initial exploration of the role of four major sex hormones on later life sexuality of both men and women using a population-based sample. The associations between sex hormone levels and sexuality are very complex and high positive correlations between sex hormone levels indicate the cascading, interdependent pathway of sex hormone production in

humans. This study also revealed different effects of sex hormones on male and female sexuality. Understanding the relationship of sex hormones to various aspects of sexual function and sexual problems requires analytic methods that can account for the physiologic interrelation between sex hormones and that can examine the biologic effects in relation to psychosocial and contextual effects on later life sexuality.

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Table 1. Population distributions across demographic subgroups and self-rated health, by gender in the National Social Life, Health and Aging Project (NSHAP).

. Values are numbers (percentages). †

	Men N=1,455	Women N=1,550
Age		
57-64	528 (43.6)	492 (39.2)
65-74	547 (35.0)	545 (34.8)
75-85	380 (21.43)	513 (26.1)
Self-reported Race		
White	1133 (85.6)	1162 (84.4)
Black	224 (9.2)	285 (10.8)
Other	94 (5.3)	99 (4.9)
Education		
Less than HS graduate	319 (16.8)	380 (20.1)
HS graduate	343 (24.3)	450 (29.5)
Some college or associate's degree	390 (27.4)	466 (32.5)
Bachelor's degree or higher	403 (31.5)	254 (17.9)
Marital status		
Married	1069 (77.9)	732 (55.5)

Living with a partner	30 (1.9)	30 (2.4)
Separated or divorced	154 (8.9)	218 (13.6)
Widowed	151 (8.1)	510 (25.1)
Never married	51 (3.2)	60 (3.4)
Self-rated health		
Poor/Fair	375 (25.5)	431 (24.2)
Good	410 (27.5)	496 (31.5)
Very good/Excellent	666 (47.0)	615 (44.3)

† Numbers and percentage estimates are weighted to account for differential probabilities of selection and differential non-response.

Table 2. Mean and median salivary sex hormone values in pg/ml by gender in a probability sample of older adult participants in the National Social Life, Health and Aging Project (NSHAP).

	Men N=1,287*		Women N=1,302*	
Sex Hormone	Mean value, SEM	Median value (range)	Mean value, SEM	Median value (range)
Estradiol	10.65 ±-0.56	6.24 (0.5-303.49)	10.03 ± 0.56	6.73 (0.5-320)
Testosterone**	99.50 ±- 6.54	77.56 (3.81-4024.2)	46.34 ± 0.76	42.93 (0.5-217.43)
Progesterone	49.52 ±-6.25	29.79 (2.0-2438.3)	60.82 ± 15.16	24.60 (2.0-12150)
DHEA**	61.22 ± 4.70	39.69 (2.0-5000)	45.92 ± 1.68	33.41 (2.0-449.7)

* This number reflects the actual number of samples appropriate for salivary hormone measurements (after samples having freezing problems were removed from the analyses).

** statistically significant gender differences in mean values ($p<0.01$)

Table 3. Adjusted correlations of log-transformed sex hormones with each other[†].

	P	E2	DHEA
Men:			
Testosterone (T)	0.45***	0.30***	0.48***
Progesterone (P)		0.42***	0.42***
Estradiol (E2)			0.27***
Women			
Testosterone (T)	0.41***	0.25***	0.64***
Progesterone (P)		0.34***	0.43***
Estradiol (E2)			0.23***

*** $p<0.001$

[†] adjusted for age, race/ethnicity, education status and smoking status

Table 4.
Association of sex hormone levels with self-rated health, sexual activity and problems in older men and women[†].
Odds ratios[††] (95% CI) of having specific condition or sexual problem[†††].

Variable	**DHEA**	**Testosterone (T)**	**Estradiol (E2)**	**Progesterone (P)**	**High androgens (DHEA and T in the upper quartile range)**
Very good or Excellent Self-rated health					
Men	1.08 (0.85-1.38)	1.04 (0.77-1.40)	0.92 (0.79 - 1.07)	1.08 (0.83 - 1.41)	**1.37* (1.01 - 1.85)**
Women	1.17 (0.93 - 1.47)	0.89 (0.62 - 1.27)	**0.84* (0.73 - 0.96)**	**1.23** (1.06 - 1.42)**	0.49 (0.21 - 1.17)
Sexual activity with a partner					

In previous 12 mo.					
Men	1.06 (0.85 - 1.32)	1.28 (0.92 - 1.77)	1.01 (0.86 - 1.18)	0.88 (0.72 - 1.07)	0.80 (0.49 1.31)
Women	1.05 (0.86 - 1.30)	1.15 (0.84 - 1.58)	1.03 (0.89 - 1.19)	0.95 (0.81 - 1.11)	1.11 (0.49 - 2.47)
>=2-3 times per mo					
Men	0.90 (0.69 - 1.17)	1.07 (0.74 - 1.53)	1.14 (0.94 - 1.38)	1.13 (0.81 - 1.58)	1.41 (0.89 - 2.21)
Women	1.38 (0.96 - 1.97)	0.61 (0.31 - 1.19)	**1.40* (1.08 - 1.82)**	1.13 (0.80 - 1.59)	1.36 0.38 - 4.84
Sexual problems					
Lack of interest in sex					
Men	0.93 (0.71 - 1.23)	1.33 (0.85 - 2.06)	1.11 (0.89 - 1.39)	**0.81* (0.67 - 0.98)**	0.84 (0.54 - 1.31)
Women	1.07 (0.77 - 1.48)	0.76 (0.42 - 1.39)	0.90 (0.71 - 1.14)	0.96 (0.78 - 1.19)	0.62 (0.15 - 2.43)
Climaxing too quickly					
Men	1.01 (0.75 - 1.33)	1.01 (0.73 - 1.39)	0.90 (0.73 - 1.12)	0.89 (0.74 - 1.07)	1.03 (0.71 - 1.49)
Women	0.92 (0.51 - 1.68)	1.39 (0.49 - 3.94)	0.82 (0.60 - 1.12)	**1.43* (1.00 - 2.05)**	3.28 (0.76 - 14.10)
Inability to climax					
Men	**0.75* (0.57 - 0.99)**	1.29 (0.85 - 1.95)	1.00 (0.82 - 1.22)	0.95 (0.71 - 1.26)	0.89 (0.53 - 1.47)
Women	0.86 (0.60 - 1.24)	0.87 (0.45 - 1.68)	0.84 (0.64 - 1.11)	1.04 (0.81 - 1.33)	0.35 (0.07 - 1.70)
Pain during intercourse					
Men	0.88 (0.38 - 2.02)	1.58 (0.58 - 4.26)	0.76 (0.40 - 1.43)	1.10 (0.71 - 1.70)	1.40 (0.44 - 4.40)
Women	0.79 (0.50 - 1.23)	1.06 (0.41 - 2.73)	0.79 (0.61 - 1.02)	1.08 (0.85 - 1.37)	0.53 (0.08 - 3.42)
Sex not					

pleasurable					
Men	0.80 (0.45 - 1.43)	1.20 (0.48 - 2.96)	0.85 (0.58 - 1.26)	1.01 (0.59 - 1.72)	**0.32* (0.11 - 0.88)**
Women	0.81 (0.51 - 1.30)	1.08 (0.60 - 1.94)	0.97 (0.70 - 1.33)	1.19 (0.91 - 1.55)	1.41 (0.33 - 5.88)
Anxiety about performance					
Men	0.86 (0.67 - 1.09)	**1.47* (1.02 - 2.12)**	0.92 (0.74 - 1.14)	**0.81* (0.65 - 1.00)**	0.89 (0.58 - 1.38)
Women	0.84 (0.45 - 1.56)	0.48 (0.15 - 1.50)	0.84 (0.57 - 1.23)	**1.45* (1.00 - 2.12)**	0.60 (0.09 3.72)
Difficulty achieving or maintaining erection (Men)	0.92 (0.69 - 1.23)	**1.50* (1.02 - 2.21)**	1.04 (0.84 - 1.28)	0.83 (0.67 - 1.02)	1.34 (0.91 - 1.97)
Difficulty with lubrication					
Women	1.09 (0.71 - 1.70)	0.54 (0.23 - 1.26)	0.84 (0.64 - 1.08)	0.95 (0.76 - 1.20)	0.27 (0.06 - 1.21)
Complex sexual morbidity					
Men	0.82 (0.65 - 1.04)	**1.50* (1.07 - 2.10)**	1.03 (0.82 - 1.29)	0.84 (0.70 - 1.02)	1.03 (0.70 - 1.51)
Women	0.89 (0.61 - 1.31)	0.77 (0.40 - 1.46)	**0.76* (0.57 - 0.99)**	1.20 (0.91 - 1.56)	0.52 (0.13 - 2.05)

† for men and women having sexual partner

†† Estimates are weighted to account for differential probabilities of selection and differential nonresponse.

††† Adjusted odds ratios are based on a logistic regression with age, race, education, self-rated health status and smoking status included as covariates, estimates separately for men and women. The confidence intervals are based on the inversion of Wald test constructed with the use of design-based standard errors.

* $p<0.05$; ** $p<0.01$

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