TESTOSTERONE AND SELF-PERCEIVED MASCULINITY IN AN AUSTRALIAN COHORT OF COMMUNITY-DWELLING MEN

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ABSTRACT

Background and objective
Traditional masculinity is characterised by traits of independence, toughness, assertiveness, competitiveness and physical competence. Multiple factors modulate the expression of masculinity, including age, social class, ethnicity and occupation. While there is a perception that physiological testosterone concentration impacts self-perceived masculinity in men, there are limited supporting data. This study aimed to examine the relationship between testosterone concentration and self-perceived masculinity as measured by the Masculinity in Chronic Disease Inventory (MCD-I), controlling for health-related and biopsychosocial factors in community-dwelling, middle-aged to elderly men.

Materials and methods
Participants were drawn from a longitudinally followed cohort (N=1195) of men participating in the Florey Adelaide Male Aging Study based in Adelaide, Australia. A final sample of 460 (mean age 65.15, standard deviation 9.72) men consisted of those with serum testosterone concentrations measured at wave one (2002–2005) and wave two (2007–2010), and who, in 2017, completed the Masculinity in Chronic Disease Inventory questionnaire and provided information related to demographics, medical conditions, health and lifestyle behaviours.

Adjusted multivariable regression analyses were undertaken to determine the relationship between serum testosterone concentration at wave 2 and MCD-1 total masculinity score and sub-scores. Given the

temporal difference between the testosterone concentration assessment and MCD-1 completion, a further analysis was performed including participants with a stable serum testosterone concentration over a 5-year period.

Results

There was no association between serum testosterone concentration and MCD-1 total masculinity score ($p = 0.54$) or sub-scores ($p = 0.12$–0.85). There was also no association between testosterone concentration and total masculinity score in men with stable serum testosterone over time ($p = 0.35$). Testosterone concentration was associated with serum sex-hormone-binding globulin (SHBG) concentration ($p < 0.001$), age ($p < 0.001$), waist circumference ($p < 0.001$) and a history of diabetes ($p = 0.021$). Total masculinity score was lower in men without a partner (widowed $p < 0.013$, separated/divorced $p < 0.019$), a history of anxiety ($p = 0.036$) and moderate ($p = 0.05$) to severe erectile dysfunction ($p < 0.001$).

Conclusion

This study provides evidence against the perception that physiological testosterone concentration impacts self-perceived masculinity. Rather, in middle-aged to older men, self-perceived masculinity is abrogated by psychosocial factors and chronic physical disorders.

Keywords: *testosterone; masculinity; MCD-I; partner; erectile dysfunction*

INTRODUCTION

"Traditional" masculinity tends to be characterised by traits such as independence, toughness, assertiveness, emotional control, competitiveness and physical competence.[1–3] The extent to which these traits are inherently biological or socially constructed is a matter of ongoing debate.[4] The expression of masculinity is modulated by multiple factors, including age, social class, ethnicity, occupation, geographical location and disability.[1,5–7] One potential biological modulating factor is the sex steroid testosterone, which is essential for the development and maintenance of male physical characteristics. It is not known whether physiological testosterone has an impact on men's self-perceived masculinity.

Artificial elevation of serum testosterone concentration in men has been associated with certain features of masculinity, such as increased sexual desire,[8,9] self-perceived dominance,[10] dominant behaviour[11] and physical strength.[12] Conversely, testosterone deficiency is associated with lack of physical strength, and more passive behaviours.[13,14] While often perceived to be the case, it is unclear, however, as to whether the concentration of physiological testosterone is associated with self-perceived identification with, or adherence to, the traditional traits of masculinity. There is only a limited number of studies examining this relationship,[15,16] and of those, only one study was undertaken in the relevant cohort (males) using salivary testosterone concentration, finding no association with masculinity.[16]

Furthermore, chronic health conditions, such as obesity and persistent depression, are associated with reductions in serum testosterone concentrations.[17,18] It is unknown as to whether these chronic diseases impact self-perceived masculinity, and if so whether it is mediated by changes in serum testosterone concentration. Whilst there are a number of different instruments to assess self-perceived masculinity,[3,19,20] the Masculinity in Chronic Disease Inventory (MCD-1) was designed to specifically evaluate masculinity in the context of chronic disease.[21,22]

In this study, we have interrogated the relationship between serum testosterone concentration and self-perceived masculinity, as measured by MCD-1, and the presence of chronic disease, and the

interaction between them in a cohort of urban, community-dwelling, middle-aged to elderly Australian men.

METHODS

Participants and Study Outline

Participants were drawn from the Florey Adelaide Male Aging Study (FAMAS) cohort, described in detail elsewhere.[23] Briefly, FAMAS comprises randomly selected, community-dwelling, male residents in the Northern and Western Statistical Local Areas of Adelaide, Australia, aged at least 35 years at recruitment.[23] Men included in the primary analysis cohort were those with complete serum testosterone concentration data from wave 1 (2002–2007) and wave 2 (2007–2010), as well as self-perceived masculinity and socio-demographic and lifestyle data, collected via postal survey conducted between 2016 and 2017 (n = 460, Figure 1).

Ethics approval was granted for the FAMAS cohort study by the Human Research Ethics Committee for the Royal Adelaide Hospital, and informed consent was obtained from all participants.

The MCD-I Questionnaire

The MCD-I is a 22-item, participant-completed questionnaire that assesses self-perceived masculinity (identification with traditional masculine traits) across six sub-domains: action approach, emotional self-reliance, physical strength, family responsibilities, optimistic capacity and sexuality. The MCD-I has been validated for use in men with prostate cancer[2] and chronic disease.[22] The MCD-I provides a total masculinity score (max 110), which is the cumulative sum of each sub-domain score.

Serum Testosterone Concentration

During clinic visits for waves 1 and 2, venous blood samples were drawn between 8:00 AM and 11:00 AM after a 12 hour overnight fast and 20 min in a sitting position. Samples were immediately placed on ice, then centrifuged, fractionated and serum was stored at −80°C before testosterone concentration was measured using an API-5000 triple quadrupole mass spectrometer (Applied Biosystems/MDS SCIEX, Toronto, Ontario, Canada). Samples from the two waves were assayed concurrently. The inter-assay coefficients of variation were: 10.1% at 0.43 nmol/L, 11.1% at 1.66 nmol/L and 4% at 8.17 nmol/L.[17]

Covariate Data

Validated, self-reported questionnaires were administered at the time of the MCD-I to collect covariate data, including socio-demographic characteristics (education, income, marital status); behavioural and lifestyle characteristics (smoking, employment); and history of being diagnosed by a doctor as having any of the following conditions: depression (yes/no), anxiety (yes/no), angina (yes/no), diabetes (yes/no), prostate cancer (yes/no) and erectile dysfunction (nil to mild, moderate, severe).[23] Waist circumference (WC) was measured to the nearest 0.1 cm using an inelastic tape maintained in a horizontal plane midway between the bottom of the ribs and the top of the iliac crest, and read from the mid-axillary line, with the participant standing comfortably with weight distribution evenly on both feet.

Statistical Analyses

Descriptive analyses were used to describe the analysis cohort characteristics at the time of administering the MCD-I questionnaire. The generalisability of the analysis cohort to those excluded from the trial at the time of admission into the FAMAS trial was examined through $\chi2$-tests and Mann–Whitney U tests to compare the baseline demographic and chronic disease measures to the initial FAMAS cohort.

Unadjusted and covariate adjusted, multivariable, linear and robust regression analyses were undertaken to examine the association between serum testosterone concentration at the FAMAS 2 time point (2007–2010) to total MCD-1 masculinity
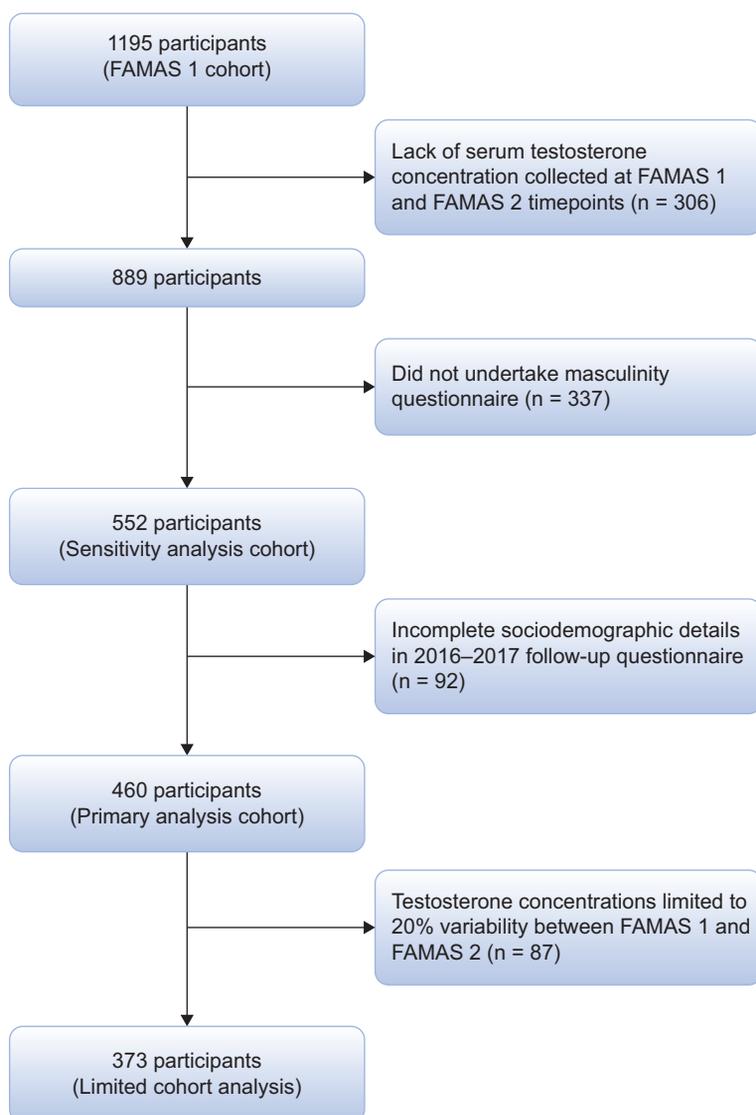
FIGURE 1 Consort diagram of FAMAS trial. Outlines the application of exclusion criteria to produce the primary analysis cohort. It simultaneously also shows process by which the sensitivity analysis cohort and limited cohort analysis were developed through relaxing and adding further exclusion criteria respectively.

score (2016–2017), and between serum testosterone concentration and each of the six sub-domain scores. Serum testosterone and sex-hormone-binding glob-ulin (SHBG) were log-transformed prior to analysis.

Two additional analyses were performed to assess the association of testosterone concentration with the self-perceived masculinity score. First, given the temporal difference between testosterone concentration measurements and MCD-I completion, a multivariable regression analysis was performed using data only from participants with minimal vari-ation in serum testosterone concentration between FAMAS 1 and FAMAS 2 waves (<20% variation, n=373, - limited cohort analysis). This is based on the premise of these participants being most likely to have ongoing static serum testosterone concentrations, and

as such, their FAMAS 2 testosterone concentrations are more likely to reflect testosterone concentration at the time of the MCD-I questionnaire completion, thereby limiting the impact of time.

Second, a sensitivity analysis was undertaken whereby the analysis was repeated on an extended cohort of participants (n=552), incorporating the primary analysis cohort and an additional 92 participants who had missing covariate data. Missing data were incorporated through naïve (mode) imputation. The only caveat to this was the erectile dysfunction data. These were the most common missing data, and it was assumed that imputation with the mode value (nil -mild erectile dysfunction) may yield false-negative results. As such, the data were imputed to an additional data value, "did not answer", for the erectile dysfunction question.

All analyses were conducted in R version 3.4.1. All p values were two-sided and p values <0.05 were considered significant.

RESULTS

Descriptive Analyses

At the time of administering the MCD-I questionnaire, most of the cohort were non-smokers (91%), married (83%) and had no history of diabetes (86%), depression (94%) or anxiety (94%). The differences between the analysis cohort and those not meeting the inclusion criteria at the time of admission are shown in Supplementary Table 1. In summary, there were many differences including: younger age (53 vs 56 years old), lower rates of smoking (19% vs 25%), lower rates of diabetes [12% vs 19%, greater proportion of married men (87% vs 78%)], smaller proportion of lower income earners <$40,000 (35% vs 52%), greater proportion of full employment (61% vs 30%), lower rates of erectile dysfunction and lower rates of prostate cancer (1% vs 4%).

By the time of MCD-I completion, more participants had retired (50%) when compared to the time of FAMAS 1 (20%), and the rate of moderate-to-severe erectile dysfunction had increased (50% vs 22%).

Testosterone and Total Self-Perceived Masculinity [β, (95% Confidence Intervals) p Value]

In unadjusted analysis, there was no association between the serum testosterone concentration and the total self-perceived masculinity score (p=0.78) (Table 2). In covariate adjusted analysis, there was also no association between the serum testosterone concentration and the total self-perceived masculinity score ($p = 0.54$, robust regression $p = 0.38$) (Table 2). Also, there was no association between the serum testosterone concentration and any of the six MCD-I sub-domain scores (Supplementary Table 2).

In the limited cohort analysis with minimal variation in the serum testosterone concentration between FAMAS 1 and FAMAS 2, there was no association between the serum testosterone concentration and the total self-perceived masculinity score ($p = 0.35$) (Supplementary Table 3). With the incorporation of the additional 92 participants with missing covariate data in the sensitivity analysis, no association between the serum testosterone concentration and the total self-perceived masculinity score was detected ($p = 0.86$) (Supplementary Table 4).

Covariate Data and Self-Perceived Masculinity [β, (95% Confidence Intervals) p Value]

After adjusting for covariates, the total self-perceived masculinity score was negatively associated with the absence of a long-term partner [widowed: −9.63, (−16.37 −2.89), 0.005; separated/divorced: −5.24, (−9.41 −1.06), 0.01], anxiety [−5.24, (−11.27 −0.17), 0.04], and severe erectile dysfunction [−8.12, (−11.78 −4.45), <0.001] (Table 2).

Middle income was the only covariate positive associated with the action approach sub-domain ($p = 0.02$), and being a smoker was associated with higher emotional self-reliance sub-domain scores ($p = 0.03$). Being widowed ($p = 0.04$) or separated/ divorced ($p = 0.03$), a history of diabetes ($p = 0.04$) or having severe erectile dysfunction ($p = 0.003$) were covariates negatively associated with the

TABLE 1 Characteristics of the Analysis Cohort (n = 460).

	Value [mean (SD) or n (%)]
Age (years)	65.2 (9.7)
Testosterone concentration (nmol/L)[+]	15.9 (5.3)
CD-I masculinity score – Total score (max 110) Sub-domain score – Action approach (max 15) – Emotional self-reliance (max 10) – Physical strength (max 25) – Family responsibilities (max 20) – Optimistic capacity (max 20) – Sexuality (max 20)	 82.6 (13.6) 11.4 (2.5) 7.0 (2.0) 18.0 (4.0) 17.1 (3.6) 15.2 (3.1) 13.9 (4.8)
Waist circumference (cm)[+]	100.5 (12.3)
Sex-hormone-binding globulin (nmol/L)[+]	37.1 (15.2)
Smoker (%)	41 (9%)
Income – Low income – <$40,000 – Middle income – $40,000–$80,000 – High income – >$80,000	 155 (34%) 166 (36%) 139 (30%)
Employment – Full-time employment – Casual employment – Retired – Other	 192 (42%) 41 (8%) 206 (45%) 21 (5%)
Education – Did not complete high school – Completed high school – TAFE/Apprenticeship* – Trade certificate or diploma – Bachelor + – Other	 111 (24%) 55 (12%) 29 (6%) 175 (38%) 73 (16) 17 (4%)
Marital status – Married or with partner – Separated/divorced – Widowed – Never married	 383 (83%) 16 (3%) 45 (10%) 16 (3%)
History of: – Prostate cancer – Anxiety in the past 12 months – Depression in the past 12 months – Angina – Diabetes	 28 (6%) 30 (7%) 29 (6%) 39 (9%) 66 (14)

TABLE 1 Continued

	Value [mean (SD) or n (%)]
Erectile dysfunction – Nil - mild difficulty – Moderate difficulty – Severe difficulty	 273 (59%) 79 (17%) 108 (24%)

[+] *All data collected at time of masculinity questionnaire completion with the exception of waist circumference, sex hormone binding globulin and serum testosterone concentration, which were taken from the FAMAS 2 timepoint due to concurrent lack of data.*
* *TAFE (Technical and Further Education) are vocational courses provided in Australia separate from University for higher learning.*

physical strength sub-domain score. Not having a partner (widowed $p < 0.001$, separated/divorced $p < 0.001$, never married $p < 0.001$) was the only covariate associated, negatively, with the family responsibilities sub-domain score. There was a negative association between the optimistic capacity sub-domain score and age ($p = 0.008$), WC ($p = 0.005$), a history of anxiety ($p < 0.001$) and severe erectile dysfunction ($p < 0.001$). The only factors associated, negatively, with the sexuality sub-domain was WC ($p = 0.02$) and moderate ($p = 0.008$) and severe ($p < 0.001$) erectile dysfunction (Supplementary Table 2).

In the sensitivity analysis, consistent findings of an association between erectile dysfunction and total masculinity score were identified. It was noted that participants who did not answer the question regarding erectile dysfunction had significantly lower masculinity scores compared to those who provided an answer [−15.2 (19.8, −10.40) <0.001] (Supplementary Table 4).

Covariates and Serum Testosterone Concentration [β, (95% Confidence Intervals) p Value]

After adjusting for covariates, the serum testosterone concentration was only positively associated with SHBG [0.52, (0.45, 0.60), <0.001], and inversely associated with age [−0.01, (−0.02, 0.005), <0.001] and WC [−0.004, (−0.007, 0.002), <0.001] (Table 3).

TABLE 2 Linear Regression Models of Perceived Masculinity in a Cohort of Middle-aged to Elderly Australian Men (n = 460).

	Simple linear regression		Multiple linear regression		Robust regression	
	Beta (confidence interval)	p value	Beta (confidence interval)	p value	Beta (confidence interval)	p value
Testosterone (log)	0.50 (−2.94, 3.93)	0.78	−1.28 (−5.41, 2.84)	0.54	−1.92 (−6.19, 2.34)	0.38
Sex-hormone-binding globulin (logarithm)	−2.44 (−5.54, 0.67)	0.12	−0.30 (−4.28, 3.67)	0.88	0.88 (−3.23, 4.99)	0.67
Age	−0.29 (−0.42, −0.17)	<0.001	0.03 (−0.19, 0.25)	0.78	−0.02 (−0.25, 0.21)	0.85
Waist circumference	−0.10 (−0.20, −0.00)	0.05	−0.01 (−0.12, 0.10)	0.92	0.02 (−0.09, 0.14)	0.68
Income						
– Low income	–	–	–	–	–	–
– Middle income	3.88 (0.94, 6.82)	0.01	1.34 (−1.73, 4.41)	0.39	1.72 (−1.45, 4.90)	0.29
– High income	6.63 (3.56, 9.70)	<0.001	1.03 (−2.84, 4.91)	0.60	1.20 (−2.81, 5.20)	0.56
Employment						
– Full time employment	–	–	–	–	–	–
– Casual employment	−1.94 (−6.43, 2.56)	0.40	0.36 (−4.32, 5.04)	0.88	−0.48 (−5.32, 4.360)	0.85
– Retired	−6.05 (−8.67, −3.43)	<0.001	−1.59 (−5.54, 2.36)	0.43	−0.73 (−4.82. 3.35)	0.73
– Other	−9.65 (−15.66, −3.65)	0.002	−4.61 (−10.91, 1.70)	0.15	−3.74 (−10.26, 2.78)	0.26
Education						
– Did not complete high school	–	–	–	–	–	–
– Completed high school	0.92 (−3.50, 5.35)	0.68	0.12 (−4.06, 4.30)	0.96	0.08 (−4.24, 4.41)	0.97
– TAFE/apprenticeship	2.82 (−2.77, 8.42)	0.32	0.81 (−4.53, 6.15)	0.77	0.26 (−5.79, 5.27)	0.93
– Trade certificate or diploma	1.96 (−1.29, 5.22)	0.24	0.90 (−2.24, 4.04)	0.57	0.72 (−2.52, 3.97)	0.67
– Bachelor +	−0.67 (−4.71, 3.38)	0.75	−1.55 (−5.54, 2.45)	0.45	−1.42 (−5.55, 2.72)	0.51
– Other	−0.22 (−7.21, 6.77)	0.95	−0.15 (−6.80, 6.50)	0.97	−0.37 (−7.24, 6.51)	0.92
Marital status						
– Married or with partner	–	–	–	–	–	–
– Widowed	−13.1 (−19.82, −6.43)	<0.001	−9.63 (−16.37, −2.89)	0.005*	−9.21 (−16.18, −2.24)	0.013*
– Separated/divorced	−6.8 (−10.41, −2.15)	0.003	−5.24 (−9.41, −1.06)	0.014*	−5.21 (−9.53, −0.90)	0.019*
– Never married	−1.75 (−8.44, 4.95)	0.61	−2.89 (−9.57, 3.78)	0.40	−4.20 (−11.11, 2.70)	0.23
Smoking	2.24 (−2.14, 6.63)	0.32	0.92 (−3.35, 5.20)	0.67	0.64 (−3.78, 5.06)	0.78
Prostate cancer	−5.07 (−10.27, 0.14)	0.06	−1.96 (−7.19, 3.28)	0.46	−1.53 (−6.94, 3.89)	0.59
Anxiety	−10 (−15.01, −5.06)	<0.001	−5.24 (−11.27, −0.17)	0.04*	−6.19 (−11.92, −0.45)	0.04*
Depression	−7.76 (−12.85, −2.67)	<0.003	−2.21 (−7.90,3.48)	0.45	−2.14 (−8.03, 3.74)	0.48
Angina	−3.98 (−8.45, 0.49)	0.08	0.06 (−4.35, 4.47)	0.98	0.83 (−3.73, 5.40)	0.72
Diabetes	−4.91 (−8.45, −1.37)	0.007	−3.35 (−6.90, 0.28)	0.06*	−4.30 (−8.01, −0.59)	0.25
Erectile dysfunction						
– Moderate	−4.74 (−8.00, −1.47)	0.005	−3.35 (−6.90, 0.19)	0.06*	−3.67 (−7.33, 0.00)	0.05*
– Severe	−10 (−12.90, −7.09)	<0.001	−8.12 (−11.78, −4.45)	<0.001*	−9.50 (−13.30, −5.71)	<0.001*

Significant factors found to correlate with total masculinity score include: marital status, anxiety, diabetes mellitus and erectile dysfunction

TABLE 3 Linear Regression Models of Serum Testosterone Concentration in a Cohort of Middle Aged to Elderly Australian Men (n = 460).

	Simple linear regression		Multiple linear regression		Robust regression	
	Beta (confidence interval)	p value	Beta (confidence interval)	p value	Beta (confidence interval)	p value
Sex-hormone-binding globulin (logarithm)	0.46 (0.38, 0.53)	<0.001	0.52 (0.45, 0.60)	<0.001*	0.57 (0.52, 0.63)	<0.001*
Age	0.00 (−0.01, 0.00)	0.02	−0.01 (−0.02, −0.01)	<0.001*	−0.01 (−0.01, −0.01)	<0.001*
Waist circumference	−0.01 (−0.01, −0.01)	<0.001	0.00 (−0.01, 0.00)	<0.001*	0.00 (−0.01, −0.00)	<0.001*
Income						
– Low income	–	–	–	–	–	–
– Middle income	0.05 (−0.04, 0.13)	0.27	−0.01 (−0.08, 0.06)	0.72	0.02 (−0.04, 0.07)	0.49
– High income	0.04 (−0.05, 0.12)	0.39	−0.03 (−0.12, 0.06)	0.54	0.01 (−0.05, 0.08)	0.69
Employment						
– Full time employment	–	–	–	–	–	–
– Casual employment	0.01 (−0.12, 0.13)	0.94	0.04 (−0.06, 0.15)	0.43	0.04 (−0.05, 0.12)	0.38
– Retired	−0.08 (−0.15, −0.01)	0.027	0.01 (−0.08, 0.10)	0.80	0.02 (−0.05, 0.09)	0.52
– Other	−0.08 (−0.25, 0.08)	0.31	0.06 (−0.09, 0.12)	0.45	0.06 (−0.05, 0.17)	0.27
Education						
– Did not complete high school	–	–	–	–	–	–
– Completed high school	0.03 (−0.09, 0.15)	0.65	0.01 (−0.09, 0.11)	0.84	0.00 (−0.07, 0.08)	0.94
– TAFE/apprenticeship	0.04 (−0.11, 0.19)	0.57	−0.04 (−0.16, 0.08)	0.50	0.01 (−0.09, 0.10)	0.86
– Trade certificate or diploma	−0.05 (−0.14, 0.04)	0.37	0.00 (−0.07, 0.07)	0.96	0.00 (−0.06, 0.05)	0.97
– Bachelor +	0.07 (−0.03, 0.18)	0.18	0.03 (−0.07, 0.12)	0.57	0.01 (−0.06, 0.07)	0.84
– Other	0.04 (−0.15, 0.22)	0.69	0.08 (−0.07, 0.24)	0.28	0.08 (−0.04, 0.19)	0.19
Marital status						
– Married or with partner	–	–	–	–	–	–
– Widowed	−0.05 (−0.24, 0.13)	0.57	0.10 (−005, 0.26)	0.19	0.04 (−0.08, 0.16)	0.50
– Separated/divorced	0.01 (−0.11, 0.12)	0.88	−0.01 (−0.11, 0.08)	0.81	−0.02 (−0.09, 0.06)	0.66
– Never married	0.04 (−0.14, 0.23)	0.64	−0.01 (−0.17 0.14)	0.87	0.00 (−0.12, 0.12)	0.99
Smoking	0.08 (−0.04, 0.20)	0.19	0.01 (−0.09, 0.11)	0.87	0.02 (−0.06, 0.09)	0.67
Prostate cancer	0.01 (−0.13, 0.15)	0.91	0.08 (−0.04, 0.19)	0.22	0.05 (−0.04, 0.14)	0.29
Anxiety	0.03 (−0.11, 0.16)	0.69	0.12 (−0.01, 0.24)	0.07	0.08 (−0.01, 0.18)	0.09
Depression	−0.07 (−0.21, 0.06)	0.30	−0.11 (−0.24, 0.02)	0.09	−0.01 (−0.11, 0.09)	0.81
Angina	−0.10 (−0.22, 0.02)	0.12	−0.05 (−0.15, 0.05)	0.33	0.01 (−0.07, 0.09)	0.75
Diabetes	−0.15 (−0.24, 0.05)	0.002	−0.05 (−0.13, 0.03)	0.23	−0.08 (−0.14, −0.01)	0.021*
Erectile dysfunction						
– Moderate	−0.03 (−0.12, 0.06)	0.52	−0.01 (−0.08, 0.09)	0.88	0.00 (−0.06, 0.07)	0.93
– Severe	−0.13 (−0.21, −0.04)	0.003	−0.08 (−0.16, 0.00)	0.06	−0.06 (−0.12, 0.01)	0.08

Significant factors found to correlate with serum testosterone concentration include: sex hormone binding globulin concentration, age, waist circumference, and diabetes

On robust regression, testosterone concentration was also negatively associated with a history of diabetes [−1.37, (−2.24, −0.50), 0.003]. History of diabetes is the only covariate variable that was associated with both testosterone concentration and masculinity score.

DISCUSSION

In this study of middle-aged to older community-dwelling men, serum testosterone was not associated with self-perceived masculinity, as reported by the MCD-I total score or any masculinity sub-domain score. The data were instead consistent with the notion that masculinity is most strongly related to physical and psychological health, rather than social constructs.[24]

The primary outcome accords with the only similar study identified assessing men (71 men aged 19–24 years), which also was unable to identify a relationship between salivary testosterone and self-perceived masculinity, as assessed by the Bem Sex-Role Inventory Questionnaire.[16] The only other study identified[15] assessed gender roles in females, and is as such deemed not applicable to this study.

The psychological and physical condition factors negatively impacting self-perceived total MCD-1 masculinity score or its sub-domains were moderate or severe erectile dysfunction, anxiety and relationship status. The most significant factor was moderate or severe erectile dysfunction. This accords with a meta-analysis showing a strong relationship between sexual dysfunction and diminished masculinity in men who have been treated for prostate cancer.[25] In the sensitivity analysis, it was also noted that a lack of response to questions regarding erectile dysfunction was also associated with a significantly reduced masculinity score (15.1 point reduction, compared to 8.2 point reduction for severe erectile dysfunction). The cause for this different is unknown.

Anxiety and mental health disorders have previously been positively associated with "masculine discrepancy,"[26] and conformity to specific masculine norms, such as self-reliance or power over women (as determined by the Conformity to Masculine Norms Inventory-94), have been associated with negative mental health outcomes.[27] Our study assessed the relationship between anxiety and self-perceived masculinity, finding consistent results of the two being intrinsically linked, in particular in the optimism domain of the MCD-I questionnaire.

Adherence to traditional masculinity roles has previously been identified as a key component to compliance with diabetes self-care,[28,29] where generally self-care is not considered a masculine norm. We have been unable to identify any prior studies assessing the impact of diabetes on an individuals' sense of masculinity based on objective questionnaire data. In a qualitative study, it was identified that men either engaged with, or rejected, medical knowledge to regain their competency lost in the diagnosis of an illness.[30] Taken together, our data relating to chronic disease and masculinity indicate that higher perceived masculinity may be associated with better health status or response to new health status.[31–33]

Self-perceived masculinity has previously been found to be modulated by multiple factors, including age, social class, ethnicity, occupation, geographical location and disability.[1,3–7] In our study, relationship status was strongly associated with MCD-I masculinity scores. Relationship status was positively influential across multiple domains (physical strength and family responsibility) of self-perceived masculinity, rather than a single component. Only two prior studies regarding masculinity and marital status have been identified in the literature. One study, using the Personal Attributes questionnaire with 87 men and 183 women, identified that the instrumental (masculine) scale was related to marital status, with married men having higher scores, with no similar impact in females.[34] The second was a qualitative assessment of 19 early male widowers, which identified that the men felt a loss of masculinity as they are thrust into a new role, and attempt to reclaim their masculinity through work or marriage.[35]

The major strengths of the current study are: the large well-characterised, longitudinally followed cohort of community-dwelling men; the measurement of serum testosterone in fasted morning samples using triple quadrupole mass spectrometry; and the use of a contextually appropriate and validated instrument to assess self-perceived masculinity in middle-aged to elderly men, including those with chronic health conditions. The concordance with the findings of others using a range of different masculinity assessment tools is reassuring,[16,25,26,28,29] albeit these studies being not undertaken in a similar cohort of middle-aged to elderly men, and not undertaken with a masculinity questionnaire contextualised for chronic disease.

The major limitation of this study is the temporal difference between when serum testosterone concentrations were measured and when the MCD-I questionnaire was administered. To address this, the multivariable analysis was repeated only using data from participants who had minor changes in the serum testosterone concentration between wave 1 and wave 2 assessments (5 years). The major results in these cohorts were relatively unchanged. The MCD-I was administered at only one time point, and accordingly the cross-sectional nature of the analyses precludes assessment of directionality

This study provides evidence against the perception that physiological testosterone concentrations impact self-perceived masculinity, but rather characteristics of masculinity are abrogated by chronic psychological and physical disorders. The implications of this on disease-related behaviour and health services is currently undetermined, and further investigation into the impact of modification of these factors is required.

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SUPPLEMENTARY TABLE 1   Comparison between Analytic Cohort and Those Not Meeting the Inclusion Criteria (at time of Recruitment – FAMAS 1).

		Excluded cohort (n=735)	Analysis cohort (n=460)	*p* value
Age – years (mean)		56.4	52.9	<0.001
Serum testosterone concentration – nmol/L (mean)		16.24	17.15	0.34
Waist circumference – cm (mean)		100.7	100.8	0.92
Smoking	Yes	182 (25%)	87 (19%)	0.02
Marital status	Married/living with partner	576 (78%)	398 (86%)	0.008
	Separated/divorced	91 (12%)	35 (8%)	
	Widowed	25 (3%)	8 (2%)	
	Never married	41 (6%)	19 (4%)	
	Did not complete	2 (0%)	0 (0%)	
Diabetes	Yes	143 (19%)	57 (12%)	0.002
Depression	Yes	95 (13%)	54 (12%)	0.61
Anxiety	Yes	68 (9%)	43 (9%)	1
Education	Trade/apprenticeship	254 (35%)	143 (31%)	0.07
	Certificate/Diploma	178 (24%)	125 (27%)	
	Bachelor's degree or higher	76 (10%)	69 (15%)	
	Don't know	9 (1%)	5 (1%)	
	Did not complete	218 (30%)	118 (26%)	
Income	<$40,000	383 (52%)	159 (35%)	<0.001
	40,001–$80,000	229 (31)	208 (45%)	
	>$80,000	106 (14%)	89 (19%)	
	Did not complete	17 (2%)	4 (1%)	
Employment	Full-time work	218 (30%)	279 (60%)	<0.001
	Part-time work	69 (9%)	44 (10%)	
	Unemployed	23 (3%)	9 (2%)	
	Retired	257 (35%)	93 (20%)	
	Other	67 (9%)	35 (8%)	
	Did not complete	1 (0%)	0 (0.00%)	
Angina	Yes	55 (7%)	23 (5%)	0.12
Erectile dysfunction	Did not answer	16 (2%)	4 (1%)	<0.001
	Mild	472 (64%)	359 (78%)	
	Moderate	35 (5%)	12 (3%)	
	Severe	212 (29%)	85 (18%)	
Prostate cancer	Yes	29 (3.95%)	4 (1%)	0.002

SUPPLEMENTARY TABLE 2 MCD-1 Masculinity Sub-domain Scores Multivariable Linear Regression Model in a Cohort of Middle-aged to Elderly Australian Men (n = 460).

Sub-domains	Action approach		Emotional self-reliance		Physical strength		Family responsibilities		Optimistic capacity		Sexuality	
	Beta (95% CI)	p	Beta (95% CI)	p	Beta (95% CI)	p	Beta (95% CI)	p	Beta (95% CI)	p	Beta (95% CI)	p
Testosterone (log)	-0.37 (-1.15, 0.42)	0.36	0.12 (-0.55, 0.76)	0.75	-0.39 (-1.64, 0.86)	0.54	-0.88 (-1.98, 0.22)	0.12	0.09 (-0.86, 1.05)	0.85	0.16 (-1.12, 1.43)	0.81
SHBG (log)	-0.11 (-0.87, 0.64)	0.77	-0.32 (-0.95, 0.31)	0.32	0.31 (-0.89, 1.52)	0.61	0.46 (-0.59, 1.52)	0.39	-0.12 (-1.03, 0.80)	0.81	-0.54 (-1.77, 0.69)	0.39
Age	0.02 (-0.02, 0.07)	0.27	0.01 (-0.03, 0.04)	0.65	0.01 (-0.06, 0.08)	0.80	-0.01 (-0.07, -0.05)	0.77	0.07 (0.02, 0.12)	0.008*	-0.07 (-0.14, 0.00)	0.05*
Waist circumference	0.02 (-0.01, 0.04)	0.16	-.00 (-0.02, 0.01)	0.73	-0.02 (-0.05, 0.02)	0.36	0.00 (-0.03, 0.03)	0.88	0.04 (0.01, 0.06)	0.005*	-0.04 (-0.07, -0.01)	0.02*
Income												
– Low	–		–		–		–		–		–	
– Middle	0.69 (0.10, 1.27)	0.02*	-0.21 (-0.70, 0.28)	0.40	0.11 (-0.82, 1.04)	0.81	-0.13 (-0.95, 0.69)	0.75	0.58 (-0.13, 1.29)	0.11	0.31 (-0.64, 1.26)	0.52
– High	0.71 (-0.02, 1.45)	0.06	-0.18 (-0.80, 0.43)	0.56	-0.07 (-0.82, 1.04)	0.90	-0.11 (-1.14, 0.92)	0.83	0.58 (-0.32, 1.47)	0.20	0.11 (-1.09, 1.31)	0.85
Employment												
– Full time	–		–		–		–		–		–	
– Casual	0.01 (-0.88, 0.89)	0.99	-0.35 (-1.09, 0.40)	0.36	0.575 (-0.84, 1.99)	0.43	-0.42 (-1.66, 0.83)	0.51	-0.08 (-1.16, 1.00)	0.89	0.62 (-0.83, 2.07)	0.40
– Retired	-0.20 (-0.95, 0.55)	0.59	-0.16 (-0.78, 0.47)	0.62	-0.202 (-1.40, 1.00)	0.74	-0.38 (-1.43, 0.67)	0.47	0.26 (-1.17, 0.66)	0.58	-0.39 (-1.61, 0.84)	0.53
– Unemployed	-1.01 (-2.21, 0.18)	0.10	-0.25 (-1.25, 0.75)	0.62	-0.955 (-2.87, 0.96)	0.33	-1.04 (-2.72, 0.64)	0.22	0.83 (-2.29, 0.63)	0.27	-0.52 (-2.46, 1.44)	0.60
Education												
– Did not finish school	–		–		–		–		–		–	
– High school	0.02 (-0.78, 0.81)	0.97	-0.03 (-0.70, 0.63)	0.92	-0.732 (-2.00, 0.54)	0.26	0.20 (-0.92, 1.31)	0.73	0.09 (-0.88, 1.06)	0.85	0.58 (-0.71, 1.88)	0.38
– TAFE/apprenticeship	0.33 (-0.68, 1.35)	0.52	0.75 (-0.10, 1.59)	0.08	-0.183 (-1.80, 1.44)	0.62	-0.01 (-1.43, 1.41)	0.99	0.11 (-1.13, 1.34)	0.87	-0.18 (-1.84, 1.47)	0.83
– Trade certificate/diploma	0.32 (-0.28, 091)	0.30	0.13 (-0.37, 0.63)	0.61	-0.433 (-1.38, 0.52)	0.37	0.18 (-0.65, 1.02)	0.67	0.24 (-1.13, 1.34)	0.52	0.47 (-0.51, 1.44)	0.35
– Bachelor+	0.20 (-0.56, 0.96)	0.60	-0.12 (-0.75, 0.52)	0.72	-0.731 (-1.94, 0.48)	0.24	0.88 (-1.95, 0.18)	0.10	0.15 (-0.78, 1.07)	0.75	-0.16 (-1.40, 1.07)	0.80
– Other	0.13 (-1.13, 1.39)	0.84	-0.54 (-1.60, 0.51)	0.31	-0.554 (-2.57, -1.46)	0.59	-0.13 (-1.90, 1.64)	0.87	-0.24 (-1.78, 1.29)	0.76	1.19 (-0.87, 3.25)	0.26
Marital status												
– Married or with partner	–		–		–		–		–		–	
– Widowed	-1.00 (-2.27, 0.28)	0.13	-0.95 (-2.02, 0.12)	0.08	-2.10 (-4.14, -0.06)	0.04*	-3.22 (-5.01, 1.43)	<0.001*	-1.47 (-3.02, 0.09)	0.07	-0.90 (-2.99, 1.19)	0.40
– Separated/divorced	-0.19 (-0.98, 0.61)	0.65	-0.15 (-0.81, 0.52)	0.66	-1.40 (-2.66, -0.14)	0.03	-2.38 (-3.49, -1.27)	<0.001*	-0.61 (-1.57, 0.36)	0.22	-0.52 (-1.81, 0.77)	0.43
– Never married	0.50 (-0.78, 1.77)	0.44	0.31 (-0.75, 1.37)	0.57	-0.40 (-2.42, 1.63)	0.70	-4.37 (-6.14, -2.59)	<0.001*	0.51 (-1.04, 2.05)	0.52	0.55 (-1.51, 2.62)	0.60
Smoking	-0.18 (-0.99, 0.64)	0.67	0.78 (0.10, 1.46)	0.03*	-0.45 (-1.74, 0.85)	0.50	0.10 (-1.04, 1.23)	0.87	0.29 (-0.70, 1.27)	0.57	0.38 (-0.94, 1.71)	0.57
Prostate cancer	0.05 (-0.94, 1.05)	0.92	-0.42 (-1.25, 0.41)	0.32	0.14 (-1.45, 1.73)	0.86	-0.53, (-1.93, 0.86)	0.45	-0.09 (-1.30, 1.12)	0.89	-1.11 (-2.73, 0.52)	0.18
Anxiety	-1.05 (-2.10, 0.00)	0.05*	-0.58 (-1.46, 0.30)	0.20	-0.01 (-1.69, 1.67)	0.99	-1.42 (-2.89, 0.06)	0.06	-2.63 (-3.91, -1.35)	<0.001*	-0.04 (-1.76, 1.68)	0.97
Depression	-0.26 (-1.34, 0.82)	0.64	0.47 (-0.43, 1.37)	0.31	-1.25 (-2.98, 0.47)	0.15	-0.02 (-1.53, 1.50)	0.98	-0.74 (-2.06, 0.57)	0.27	-0.41 (-2.17, 1.36)	0.65
Angina	0.12 (-0.72, 0.96)	0.78	0.13 (-0.57, 0.83)	0.71	-0.06 (-1.40, 1.28)	0.93	-0.56 (-1.74, 0.61)	0.35	0.11 (-0.91, 1.13)	0.84	0.33 (-1.04, 1.69)	0.64
Diabetes	-0.66 (-1.34, 0.03)	0.06	-0.08 (-0.65, 0.49)	0.78	-1.17 (-2.25, -0.08)	0.04*	-0.74 (-1.69, 0.22)	0.13	-0.32 (-1.14, 0.51)	0.46	-0.36 (-1.47, 0.75)	0.52
Erectile dysfunction												
– Nil – mild	–		–		–		–		–		–	
– Moderate	-0.44 (-1.11, 0.23)	0.20	0.41 (-0.15, 0.97)	0.15	-1.10 (-2.17, -0.02)	0.05*	-0.15 (-1.09, 0.79)	0.75	-0.58 (-1.40, 0.24)	0.16	-1.50 (-2.60, -0.40)	0.008*
– Severe	-0.64 (-1.34, 0.05)	0.070	0.44 (-0.14, 1.02)	0.14	-1.71 (-2.82, -0.60)	0.003*	-0.02 (-0.99, 0.96)	0.98	-1.65 (-2.50, -0.81)	<0.001	-4.54 (-5.67, -3.40)	<0.001*

Significant factors found to correlate with each subdomain are the following:

Action approach: Income and anxiety

Emotional self-reliance: Smoking

Physical strength: Marital status, diabetes mellitus and erectile dysfunction

Family responsibility: Marital status

Optimistic capacity: Age, waist circumference and anxiety

Sexuality: Age, waist circumference and erectile dysfunction

SUPPLEMENTARY TABLE 3   Cohort Characteristics and Linear Regression Model of Masculinity Total Component of MCDI Questionnaire in a Cohort of Middle-aged to Elderly Australian Men with Limited Variation in Serum Testosterone Concentration (n = 373).

	Cohort characteristics	Multiple linear regression	
	Value [mean (SD) or n (%)]	Beta (95% confidence interval)	*p* value
Masculinity score	82.13(13.68)	–	
Testosterone (logarithm)	15.91 (5.00)	–2.94 (–9.11, 3.23)	**0.35**
Sex-hormone-binding globulin (logarithm)	37.03 (15.83)	1.10 (–3.88, 6.07)	**0.66**
Age	65.36 (9.76)	0.01 (–0.24, 0.26)	**0.94**
Waist circumference	99.98 (12.28)	0.01 (–0.12, 0.13)	**0.94**
Income – Low income – Middle income – High income	134 (36%) 133(36%) 106 (28%)	– 0.65 (–2.80, 4.11) 0.20 (–4.19, 4.60)	**0.71** **0.93**
Employment – Full-time employment – Casual employment – Retired – Other	148 (40%) 35 (9%) 173 (46%) 17 (5%)	– 0.44 (–4.76, 5.64) –0.85 (–5.34, 3.64) –3.47 (–10.62, 3.69)	**0.87** **0.71** **0.34**
Education – Did not complete high school – Completed high school – TAFE/apprenticeship – Trade certificate or diploma – Bachelor + – Other	88 (24%) 48 (13%) 24 (6%) 140 (38%) 57 (15%) 16 (4%)	– 1.47 (–3.19, 6.13) 1.49 (–4.53, 7.50) 1.23 (–2.36, 4.82) –0.14 (–4.79, 4.50) 0.48 (–6.61, 7.56)	**0.54** **0.63** **0.50** **0.95** **0.90**
Marital status – Married or with partner – Widowed – Separated/divorced – Never married	312 (84%) 36 (10%) 11 (3%) 14 (4%)	– *–12.70 (–20.99, –4.41)* *–6.30 (–11.04, –1.56)* –2.19 (–9.57, 5.18)	*0.003** *0.009** **0.56**
Smoking	36 (10%)	1.42 (–3.26, 6.10)	**0.55**
Prostate cancer	24 (6%)	–2.64 (–8.42, 3.14)	**0.37**
Anxiety	26 (7%)	–3.94 (–9.94, 2.06)	**0.20**
Depression	24 (6%)	–1.88 (–8.21, 4.44)	**0.56**
Angina	29 (8%)	–1.00 (–6.19, 4.20)	**0.71**
Diabetes	54 (14%)	–3.10 (–7.19, 0.98)	**0.14**
Erectile dysfunction – Nil-mild – Moderate – Severe	227 (61%) 61 (16%) 85 (23%)	– *–4.83 (–8.98, –0.68)* *–8.11 (–12.34, –3.88)*	*0.023** *<0.001**

* Significant factors found to correlate with total masculinity score in the subjects with limited changes in serum testosterone concentration include marital status and erectile dysfunction

SUPPLEMENTARY TABLE 4 Participant Characteristics and Linear Regression Models of Perceived Masculinity in a Sensitivity Analysis Cohort (n = 552)

	Mean (SD) or n (%)*	Simple linear regression		Multiple linear regression		Robust regression	
		Beta (95% CI)	p value	Beta (95% CI)	p value	Beta (95% CI interval)	p value
Testosterone (log)	15.85 (5.41)	1.14 (−1.91, 4.18)	0.47	0.31 (−3.11, 3.74)	0.86	0.25 (−3.20, 3.70)	0.89
SHBG (log)	37.9 (16.6)	−4.66 (−7.60, −1.73)	0.002	−2.54 (−6.09, 1.01)	0.16	−1.39 (−4.97, 2.18)	0.45
Age	66 (10)	−0.34 (−0.46, −0.22)	<0.001	−0.01 (−0.21, 0.19)	0.91	−0.05 (−0.25, 0.15)	0.61
Waist circumference	100.3 (12.2)	−0.07 (−0.17, 0.02)	0.14	0.00 (−0.10, 0.10)	0.98	0.03 (−0.08, 0.13)	0.63
Income							
– Low	182 (33%)						
– Middle	184 (33%)	3.52 (0.73, 6.32)	0.014	−0.33 (−3.08, 2.41)	0.81	0.49 (−2.28, 3.26)	0.73
– High	149 (27%)	6.8 (3.84, 9.75)	<0.001	−0.37 (−4.02, 3.29)	0.84	0.20 (−3.48, 3.88)	0.91
– Did not answer	37 (6%)						
Employment							
– Full-time employment	208 (38%)	−1.85 (−6.31, 2.61)	0.42	−0.47 (−4.96, 4.02)	0.84	−1.15 (−5.67, 3.37)	0.62
– Casual employment	45 (8%)	−7.52 (−10.02, −5.02)	<0.001	−1.83 (−5.50, 1.83)	0.33	−1.13 (−4.82, 2.57)	0.55
– Retired	270 (49%)	−9.35 (−14.90, −3.81)	<0.001	−2.56 (−8.26, 3.15)	0.38	−1.66 (−7.41, 4.09)	0.57
– Other	27 (5%)						
– Did not answer	2 (0%)						
Education							
– Did not complete high school	138 (25%)						
– Completed high school	65 (12%)	1.69 (−2.55, 5.93)	0.43	0.34 (−3.55, 4.24)	0.86	−0.01 (−3.94, 3.91)	1.00
– TAFE/apprenticeship	33 (6%)	2.53 (−2.93, 7.99)	0.36	0.56 (−4.53, 5.64)	0.83	−0.24 (−5.36, 4.88)	0.93
– Trade certificate or diploma	201 (36%)	2.67 (−0.45, 5.78)	0.09	−0.01 (−2.90, 2.89)	1.00	−0.55 (−3.46, 2.37)	0.72
– Bachelor +	81 (15%)	0.87 (−3.07, 4.82)	0.67	−1.30 (−5.08, 2.49)	0.50	−1.68 (−5.49, 2.14)	0.39
– Other	20 (4%)	−1.61 (−8.35, 5.14)	0.64	−1.76 (−7.91, 4.39)	0.58	−2.82 (−9.02, 3.38)	0.37
– Did not answer	14 (3%)						
Marital status							
– Married/	444 (80%)						
– Widowed	19 (3%)	−11.50 (−17.96, −4.98)	0.001	−7.95 (−14.18, −1.73)	0.012*	−8.21 (−14.48, −1.93)	0.013*
– Separated/divorced	50 (9%)	−6.19 (−10.32, −2.06)	0.003	−5.75 (−9.76, −1.73)	0.005*	−5.44 (−9.49, −1.39)	0.009*
– Never married	22 (4%)	−6.25 (−12.30, −0.20)	0.043	−6.88 (−12.66, −1.10)	0.020*	−7.20 (−13.02, −1.38)	0.017*
– Did not answer	17 (3%)						

(Continued)

SUPPLEMENTARY TABLE 4 *Continued*

	Mean (SD) or n (%)*	Simple linear regression		Multiple linear regression		Robust regression	
		Beta (95% CI)	p value	Beta (95% CI)	p value	Beta (95% CI interval)	p value
Smoking	47 (9%)	1.95 (−2.36, 6.26)	0.38	0.69 (−3.37, 4.75)	0.74	0.02 (−4.08, 4.11)	0.99
Prostate cancer	40 (7%)	−3.03 (−7.67, 1.61)	0.2	1.02 (−3.43, 5.47)	0.65	1.37 (−3.11, 5.86)	0.55
Anxiety	34 (6%)	−10.40 (−15.36, −5.50)	<0.001	−6.66 (−11.86, −1.46)	0.012*	−6.99 (−12.23, −1.75)	0.009*
Depression	35 (6%)	−7.35 (−12.206, −2.45)	0.003	−3.13 (−8.30, 2.03)	0.23	−2.89 (−8.09, 2.32)	0.28
Angina	47 (9%)	−4.82 (−9.11, −0.52)	0.028	−1.41 (−5.48, 2.66)	0.47	−0.50 (−4.60, 3.60)	0.81
Diabetes	85 (15%)	−5.47 (−8.77, −2.16)	0.001	−3.43 (−6.68, −0.18)	0.039*	−4.20 (−7.47, −0.92)	0.013*
Erectile dysfunction							
– Nil to mild	288 (52%)	–		–		–	
– Moderate	90 (16%)	−5.090 (−8.25, −1.95)	0.002	−3.41 (−6.83, 0.02)	0.051	−3.74 (−7.19, −0.29)	0.033*
– Severe	134 (24%)	−10.50 (−3.19, −7.74)	<0.001	−8.19 (−11.62, −4.76)	<0.001*	−9.16 (−12.62, −5.70)	<0.001*
– Did not answer[+]	40 (7%)	−17.70 (−22.14, −13.35)	<0.001	−15.11 (−19.81, −10.40)	<0.001*	−15.96 (−20.70, −11.22)	<0.001*

*Significant factors found to correlate with total masculinity score in the sensitivity analysis cohort include marital status and erectile dysfunction, anxiety, diabetes and erectile dysfunction

[+] "Did not answer" cohorts underwent naïve imputation into mode subgroup with exception of erectile dysfunction.