Testosterone Levels Are Negatively Associated with Childlessness in Males, but Positively Related to Offspring Count in Fathers

Thomas V. Pollet1*, Kelly D. Cobey2, Leander van der Meij1

1 Department of Social and Organizational Psychology, VU University Amsterdam, Amsterdam, The Netherlands, 2 Department of Social Psychology, University of Groningen, Groningen, The Netherlands

Abstract
Variation in testosterone (T) is thought to affect the allocation of effort between reproductive and parenting strategies. Here, using a large sample of elderly American men (n = 754) and women (n = 669) we examined the relationship between T and self-reported parenthood, as well as the relationship between T and number of reported children. Results supported previous findings from the literature, showing that fathers had lower T levels than men who report no children. Furthermore, we found that among fathers T levels were positively associated with the number of children a man reports close to the end of his lifespan. Results were maintained when controlling for a number of relevant factors such as time of T sampling, participant age, educational attainment, BMI, marital status and reported number of sex partners. In contrast, T was not associated with either motherhood or the number of children women had, suggesting that, at least in this sample, T does not influence the allocation of effort between reproductive and parenting strategies among women. Findings from this study contribute to the growing body of literature suggesting that, among men, pair bonding and paternal care are associated with lower T levels, while searching and acquiring sex partners is associated with higher T levels.

Introduction
Humans are among a relatively restricted group of mammals, 5% or less, that display male paternal care [1,2]. It is not uncommon for fathers to provide direct care to dependent offspring well into the second decade of their life, often even caring for multiple overlapping offspring at the same time (e.g., [3,4]). As a consequence of paternal investment human males must regulate the time and energy they allocate between mating and parental effort [2,3].

Wingfield, Hegner, Duffy, and Ball’s ‘challenge hypothesis’, based on research from bird species, suggests that testosterone (T) helps to regulate the trade-off between mating and parenting [5]. Specifically, it explains the function of varied T levels in seasonally breeding birds, wherein T levels rise in the mating season and then subsequently drop during the period of brooding and parental care. The challenge hypothesis, reviewed in [6], has since been adapted to also account for changes in mating and parenting effort in humans (review in [7], example: [8]). Of course, in humans, breeding does not follow a seasonal pattern, instead human males experience high chronic T levels and can pursue mating opportunities throughout their lifespan [9]. Nonetheless, research on the life history of human males appears to support the idea that T is intricately involved in regulating mating and pair bonding/parenting behavior (for review: [10]). Low male T levels have been shown to promote features relevant to parenting or investment [7]. For example, married men are known to have lower T levels than samples of matched men who are unmarried (e.g., [11–14]). Likewise, men who are in committed relationships have been shown to have lower levels of T than uncommitted single men (e.g., [14–16]). A complementary line of research has shown that the transition to fatherhood is also associated with a decrease in T levels (e.g., [13,17–20]). The role of low T in facilitating parenting seems to be robust: in non-Western populations fathers have also been found to have lower T levels than non-fathers [17,19–21]. The adjustment of T levels upon the transition to fatherhood has been proposed to facilitate better fathering through priming men to provide care [22]. Yet, T levels have been found to be negatively related to paternal investment in three studies from non-Western cultures [17,21,23]. The notion of low levels of T being associated with nurturing responses is, however, consistent with recent laboratory based work by van Anders and colleagues [24] who showed that providing a nurturing response to a crying doll decreases male T levels. However, it should be noted that this sample consisted mostly of non-fathers. In line with van Anders et al. findings [24], men who express a greater need to comfort a

Citation: Pollet TV, Cobey KD, van der Meij L (2013) Testosterone Levels Are Negatively Associated with Childlessness in Males, but Positively Related to Offspring Count in Fathers. PLoS ONE 8(4): e60018. doi:10.1371/journal.pone.0060018

Editor: Michael Bader, Max-Delbrück Center for Molecular Medicine (MDC), Germany

Received November 25, 2012; Accepted February 20, 2013; Published April 3, 2013

Copyright: © 2013 Pollet et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Funding: This project used data collected as part of the National Social Life, Health, and Aging Project (NSHAP), and the authors are grateful to these researchers including: National Institute on Aging, Office of Research on Women’s Health and the Office of AIDS Research. Additional financial support was provided by National Opinion Research Centre. The views expressed in this paper are those of the authors and not of the ICPSR, NORC or NSHAP team. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

* E-mail: t.v.pollet@vu.nl
crying baby experience an even larger decrease in their T levels than men who do not express such a need [22]. However, a different study showed an increase in T levels among fathers in response to crying infants [25]. Moreover, to date, there is no conclusive evidence that T levels in males are negatively related to interaction with children. One study using data on Jamaican fathers [26] and one study on Filipino fathers [27] did not find any significant relationship between T levels and interaction with children. A study by Storey and colleagues found a negative relationship between amount of time spent interacting with toddlers and percent change in T levels in a sample of Canadian fathers [28].

In contrast to findings suggesting that low T levels are related to nurturing behaviors, high T levels are known to promote mating behaviors. For example, T levels are known to increase when men view sexually explicit videos [29] and after they have had sex [30]. Likewise, male T levels increase after a brief non-physical social interactions with women [8,31]. Men with elevated T levels also show more affiliative behaviors towards women [32]. Finally, high T levels are positively associated with the number of sex partners a man reports [33–35], and, more broadly, have been argued to be positively related to male reproductive effort in humans [9].

There is also evidence that T levels regulate the tradeoff between mating and parental effort in women. For example, it has been shown that single women have higher levels of T than partnered women [36], married women have lower T levels than single women [37], and mothers have lower T levels than non-mothers [37,38]. However, the evidence linking T levels to mating and parental effort is far scarcer for females than it is for males, especially when compared across species.

Here, we present data that allowed us to explore the relationship between being a parent, number of children and T levels in a sample of elderly men and women. To our knowledge, no study in humans has yet examined the relationship between T levels and breeding success for women with high T levels, as it seems unlikely that fatherhood and motherhood would broadly, have been argued to be positively related to male reproductive effort in humans [9].

Here, we present data that allowed us to explore the relationship between being a parent, number of children and T levels in a sample of elderly men and women. To our knowledge, no study in humans has yet examined the relationship between T levels and breeding success in men and women with at least one child in a large sample. We predicted, in line with the aforementioned literature, that fatherhood and motherhood would be negatively associated with T levels. In addition, we predicted that, among fathers, breeding success would be higher among men with relatively higher levels of T as these men may be more inclined to focus on mating effort. Among mothers we also explored this latter relationship, but we did not expect a higher breeding success for women with high T levels, as it seems unlikely that women would increase their number of children via mating effort in the same way men do.

Methods

1. Ethics Statement

This paper makes use of secondary data analysis of a previously collected data source, which is available to researchers via a data archive (ICPSR, www.icpsr.org). Ethical review was waived for the current research project by the Ethics Review Board (VCWE, Faculty of Psychology and Pedagogics, VU University Amsterdam). The ethics approval of the original data collection can be found in the NSHAP codebook (see: http://www.norc.org/Research/Projects/Pages/national-social-life-health-and-aging-project.aspx).

2. Dataset

Our predictions were tested using an archival dataset of older Americans aged 57–83 from the National Social Life, Health, and Aging Project (NSHAP) [N = 3,005; [39]]. Relative to the American population the dataset oversampled men, African-Americans, Latinos, and the eldest age groups. Trained interviewers from the National Opinion Research Centre (NORC) conducted the face-to-face interviews between July 2005 and March 2006. Participant response rate was 75.5% (for the full description of the data collection see [39] or [40]). At the time of the interview participants also provided several in-home biomasures (e.g. Testosterone, Cotinine) and were given a leave-behind questionnaire. We limited the sample to White participants (74% of the male working sample, n = 754; 70% of the female working sample n = 669), as exploring the relationship in other ethnicities left us with too few cases (Males: Hispanics: n = 111; African Americans: n = 129; Other n = 29; Females: Hispanics: n = 108; African Americans: n = 157; Other n = 18). While these numbers are much higher than some published samples for T and paternal behavior (e.g., [22]), given the high level of noise in these data and the small effects we expect at the end of participants’ reproductive lifespan, samples of around 150 are likely not sufficient. In addition, there are suggestions that ethnicities differ both in their T levels (e.g., [41]) as well as in their reproductive behavior (e.g., [42–44]). In ESM S1 we present the results for the full sample with all ethnicities. These results are quite similar to those reported below. However, given that the reported effects are predominately driven by White participants (>70% of working sample) and the reasons outlined above, we have chosen to report the results for White participants rather than those of the pooled sample.

3. Testosterone

Ninety percent of the overall sample complied in providing saliva samples (N = 3,005). Participants who failed to have a saliva samples taken successfully were excluded (4.5% of overall sample failed to provide a sample or provided a sample which was not valid due to equipment failure (N = 135)). Saliva samples were transported from interviews using cold packs and dry ice and were shipped to Salimetrics for analysis in duplicate (75.3% of the saliva samples provided actual T values, see [39] for further details). The procedure and assay are described in [35] and [45]. We excluded outliers of two standard deviations above the mean (>166.75 pg/ml for males; >93.58 pg/ml for females). As the key independent variable we used the mean scores of the T values from both hormone assays, which we subsequently logarithmically transformed as values did not follow a normal distribution.

4. Childlessness and Number of Living Children

Number of children and childlessness were used as the dependent variable. This was captured by the items: “How many living daughters do you have?” and “How many living sons do you have?” ([39]: p. 32-ff.). When participants asked if they should include or exclude step-sons/daughters they were told that they could include them. It is thus possible that responses to these items include non-biological children. However, we believe that the error as a result from asking about and reporting non-biological children can be considered as random noise, which is unrelated to T levels. Therefore, it seems unlikely that this noise would influence the statistical conclusions of our results.

5. Control Variables

While some findings suggest that in older men the circadian rhythm in T is blunted or even lost (see [46]), we included the time of sampling as a control variable (coded as am/pm). Further, since male T levels are known to decrease with age [47], participant age
Models. The standard errors for the models we present were
the conclusions drawn from our results were the same for both
Values are mean
sexes. All statistical tests were performed with SPSS version 16.0.
(BIC, \([54]\)) which tends to be more conservative. We presented the
reported also the Bayesian information criterion for each model
more support for model A over model B \([51]\). This procedure is an
examined a baseline model with no control variables; (2) we then
sequentially added control variables, and only maintained these
variables when they improved model fit (Akaike Information
sequentially added control variables, and only maintained these
variables when they improved model fit (Akaike Information
status (\([55]\) we controlled for
marital status. Furthermore, it is possible that any relationship
between childlessness and \(T\) is an artifact of these males being in a
committed relationship. Thus, marital status is a necessary control
variable to distinguish whether or not the effect is driven by
differences in \(T\) or differences in marital status. We also explored if
the number of opposite sex partners a participant reported
influenced our main findings, because males with higher \(T\) have
been shown to report more female sex partners (e.g., \([33–35]\)).
These findings are described in the ESM S2. The descriptive
statistics of the aforementioned control variables can be found in
ESM S3.

6. Statistical Analyses

We used Generalized linear models with Maximum Likeli-
hood estimation to analyze the data. We use negative binomial
regression to analyze childlessness (GZLM; with NBR, \([48]\)).
This method was preferred over logistic regression as it deals
with overdispersion better. For individuals with at least one
child, offspring count was analyzed via adjusted Poisson models,
given that we are dealing with skewed count data. The number
of children can be conceived as count data following a Poisson
distribution (number of events in an unknown sequence). Indeed
a Poisson model proved a much better fit to the data than a
linear model (all models AIC>50 (Poisson vs. linear), although
the conclusions drawn from our results were the same for both
models. The standard errors for the models we present were
adjusted for model deviance, and thus take into account the
under- or overdispersion in any given model \([48,49]\).

We reported model fit (AIC, BIC) and parameter statistics for
our models. Our modeling strategy was as follows: (1) we first
examined a baseline model with no control variables; (2) we then
sequentially added control variables, and only maintained these
variables when they improved model fit (Akaike Information
Criterion (AIC); smaller-is-better; \([50]\)). As a rule of thumb, two
units indicates an indistinguishable difference between models,
whereas ten units indicates a large difference between models and
more support for model A over model B \([51]\). This procedure is an
information theoretic approach which leads to the best fitting
model from our given set of variables \([52,53]\). Additionally, we
reported also the Bayesian information criterion for each model
(BIC, \([54]\)) which tends to be more conservative. We presented the
results separately for males and females, as the distributions for \(T\)
and offspring count are expected to differ significantly between the
sexes. All statistical tests were performed with SPSS version 16.0.
Values are mean \pm standard error means (SE) unless otherwise
specified. For illustrative purposes, we used raw \(T\) scores or \(Z\)
scores, rather than \(\log(T)\) scores within the (online) figures.

Results

1. Males: Childlessness

Testosterone levels were associated with male childlessness (see
Fig. 1 and Table 1). Men who reported no living children had
higher \(T\) levels \((90.79 \pm 4.11 \text{ pg/ml})\) than men with living
children \((76.46 \pm 1.04 \text{ pg/ml})\), see also Fig. 1. The Negative
Binomial Regression Model showed indeed that \(\log(T)\) was
positively associated with childlessness. This effect remained after
controlling for marital status (see model 2 in Table 1). However,
the odds ratio \((\exp(B))\) for \(\log(T)\) dropped from 21.08 to 8.48 after
inclusion of Marital Status, suggesting that the relationship
between \(\log(T)\) and childlessness is mediated by not being married.
Model 2, with marital status and \(\log(T)\) as predictors, could not be
improved by adding the other control variables \((\Delta\text{AIC}<1)\).

2. Males: Offspring Count among Men with Living
Children

When examining only men with at least one child, male \(T\) levels
were significantly and positively associated with the number of
living children (see Figure 1 and Table 2). At baseline, the model
predicts that an increase of one standard deviation from the mean
in raw \(T\) levels amounts to an increase of 12 children (see ESM
S4). The significant association between \(T\) and offspring count
remained after controlling for age and educational attainment (see
model 2 and 3 in Table 2). Older and lower educated men tended
to have more children than younger and higher educated men
respectively. Model 2 and Model 3 were virtually indistinguishable
in terms of model fit \((\Delta\text{AIC}<1)\). Using a Bayesian approach, one
would select model 2 over model 3 \((\Delta\text{BIC}>11)\). Model 3 could not
be improved by adding other control variables, such as marital
status \((\Delta\text{AIC}<1)\). As described in the endnote controlling for
the number of reported opposite sex partners or remarriage does not
alter this finding.

3. Females: Childlessness and Offspring Count

For women there was no association between \(\log(T)\) and
childlessness (Negative Binomial Regression Model; \(B = .572 +/- .44\); \(\chi^2\) test = 1.694; \(p = .193\)). Similarly, there was no association
between \(\log(T)\) and offspring count among women who reported
living children (Poisson Model; \(B = 0.071 +/- 0.109\); \(\chi^2\) test = 0.424;
\(p = .515\)).

Discussion

Three main findings emerge from this research. Firstly, we
replicated the finding that fathers have lower \(T\) levels than non-
fathers (e.g., \([13,17–19,22]\)). However, to our knowledge, this is
the first time that this has been demonstrated in a large sample of
elderly men. The decrease in \(T\) levels upon the transition to
fatherhood is thought to facilitate the allocation of energy to
activities related to parenting. Yet, there are several studies
indicating that \(T\) levels can be negatively related to paternal
investment in males \([17,21,23]\). In contrast, the notion that \(T\) is
positively related to fathering is supported, for example, by the
finding that men who experience a greater need to comfort a
crying baby experience a larger decrease in their \(T\) levels \([22]\). It is
also consistent with findings that provide a nurturing response to
crying baby actually decreases male \(T\) levels \([24]\), though the
majority of this sample consisted of non-fathers. However, it is still
unclear whether \(T\) levels and interacting with offspring are
consistently related in males \([26–28]\). Our results add to the
current literature by showing that in old age there still is a marked
significant difference between (self-reported) fathers and non-
fathers in \(T\) levels, though from this cross-sectional study it is
unclear what the mechanism driving this decrease among fathers
is. One potential mechanism could be close interaction with young
grandchildren, rather than fatherhood status per se. However, the
finding that (putative) fatherhood is associated with low \(T\) levels in
old age, seems at odds with recent findings by Gettler and
colleagues who showed that while Filipino men became fathers, \(T\) levels returned to similar levels before
fatherhood as their children aged \([17]\). These findings suggest that
longer-term effects of fatherhood on T levels are perhaps not universal and that they may differ between Western and non-Western societies.

Secondly, we showed that among elderly men who reported being fathers, those with higher T levels reported more (living) children than those with lower T levels. To our knowledge, our study is the first to demonstrate in a large sample of putative fathers that T levels are related to the reported number of children towards the end of man’s reproductive lifespan. While in theory, men in our sample may still have more offspring, they are likely to be close to the end of their reproductive lifespan as they were on average 69 years old. That fathers with higher T levels would have more children is consistent with the predictions of the Challenge Hypothesis [7] and with T being involved in mating effort in humans [9]. According to both these perspectives, in contexts where mating effort is required, e.g. to acquire sex partners, T levels are (chronically) higher. Consequently, those fathers with higher T levels may engage more frequently in attracting (additional) partners for sex, thereby increasing their likelihood to father additional children. This may be accomplished either through increased promiscuity, extramarital affairs or new marriages. Indeed, in this same dataset we have previously shown that men with higher T levels report more sex partners [35]. Similarly, previous research has shown that men with higher T levels are more likely to get divorced [12]. Taken together, these behaviors may result in the fathering of more children during their lifespan than fathers who did not engage in the acquisition of more sex partners. However, our results did not show that fathers with high T levels had more children because they remarried or because they had more sex partners. It may be that this effect was obscured because of social desirability in responses, which could especially cause men with a family (i.e., fathers) to underreport extramarital affairs.

Apart from the acquisition of more sex partners by men with high T levels, additional mechanisms are plausible. It could be that those fathers with high T levels were more fertile than those with

---

**Table 1.** Parameter estimates (B), standard errors, Exp(B), and concomitant test statistics for Negative Binomial Regression models with childlessness as dependent variable.

| Childlessness in Men | B     | SE   | Exp(B)   | p       |
|----------------------|-------|------|----------|---------|
| **Model 1**          |       |      |          |         |
| log(testosterone)    | 3.048 | 0.5486 | 21.08    | <.00001 |
| **Model 2**          |       |      |          |         |
| log(testosterone)    | 2.137 | 0.4956 | 8.475    | <.00001 |
| (ΔAIC = 53.40; ΔBIC = 34.90) |       |      |          |         |
| Marital Status       |       |      |          |         |
| Married              | −3.300| 0.1970 | 0.037    | <.00001 |
| With partner         | −1.351| 0.339  | 0.259    | <.00001 |
| Divorced/separated   | −2.328| 0.2913 | 0.097    | <.00001 |
| Widowed              | −1.901| 0.2298 | 0.149    | <.00001 |
| Never Married        | −     | −     | −        | −       |

For Marital status, ‘Never Married’ was set as reference category.

doi:10.1371/journal.pone.0060018.t001

---

**Figure 1. Number of living children and mean testosterone level for Caucasian men (n = 754).** Error bars represent 95% Confidence Intervals (10+ is only used for graphical representation analyses used the full range).
doi:10.1371/journal.pone.0060018.g001
than men with lower T levels. However, this relationship does not
and capable, and thus experience more opportunities for mating
levels have more children since they are more physically motivated
(reviewed in [60]). It could thus be that those men with high T
associated with obesity, stress and exposure to industrial pollutants
could also be a number of indirect effects of T on the number of
Furthermore, rather than a direct effect of T on fertility, there
lead to increased fertility among men who are already fertile.
certain level of T is mandatory for fertility, higher T levels do not
infertility [58]. However, when considering fertile men, a recent
study found no relationship between semen quality and T levels
[59]. This latter finding suggests that increased fertility is not a
likely explanation for our finding. It could be that, although a
certain level of T is mandatory for fertility, higher T levels do not
lead to increased fertility among men who are already fertile.
Furthermore, rather than a direct effect of T on fertility, there
could also be a number of indirect effects of T on the number of
children a man has. For example, lower T levels are positively
associated with obesity, stress and exposure to industrial pollutants
(reviewed in [60]). It could thus be that those men with high T
levels have more children since they are more physically motivated
and capable, and thus experience more opportunities for mating
than men with lower T levels. However, this relationship does not
seem that likely since we controlled for BMI, which is an
important health indicator.
Finally, we found that T levels were not associated with either
motherhood or number of living children in our female sample.
This finding is in contrast to the results of Kuzawa and colleagues
[38]. However, it is possible that among women there are no
measurable associations between T and childlessness or offspring
count at an older age, while these do exist at other periods
throughout a female’s life span, as the findings by Kuzawa and
colleagues on women in their reproductive window suggest. In
this respect, it is important to note that androgen levels of postmen-
opausal women are substantially different from those of women
of reproductive age (e.g. [61]). Moreover, the population and context
of the Philippines, is very different from that of the United States,
which likely makes the populations hard to compare [see [62,63]].
Therefore these findings are not necessarily at odds with those of
Kuzawa and colleagues [38].
There are several notable limitations to this study. Firstly, our
conclusions are based on self-reports. It could be that men with
higher T levels are more prone to boast their number of children,
or alternatively, be more likely to include stepchildren as their own
children. However, this seems unlikely since the effect of T on the
number of self-reported children was not mediated via remarriage.
Secondly, this study could not disentangle the mechanism through
which fathers with higher T levels had more children: it could be
that they had more sex partners (although they did not report
them), that they were more fertile, that they had sex with their
partner more frequently, or that they preferred sex partner(s) who
wanted relatively more children. Similarly, men with high T levels
might have actually paired with more fertile women. Thirdly, the
fathers in our study were not yet at the end of their theoretical
reproductive life span and could therefore conceive additional
children. The survey items also specifically asked participants to
report on the number of living children. One implication of our this
finding is that fathers with high T could invest less time towards
caring for children, which could potentially reduce the quality, health
or even survival of their offspring. If it is true that survivorship of
children was affected by high T fathers, findings reported herein
may be somewhat underestimated. Finally, our interpretation of
the relationship between number of offspring and T levels assumes
that individual differences in T levels demonstrate some stability
over time. Indeed, there is some evidence that this so, since it has
been shown in a longitudinal study covering 30 years that male
T is at least moderately correlated (r = 0.5, [64]). The results
from this study contribute to the growing literature that shows that
pair bonding and paternal care are associated with low T levels,
while searching for and acquiring sex partners is associated with
high T levels. An interesting avenue to pursue in future research
could be to look more closely at how age of children or contact
with children might interact with the effects reported herein.
Future research on T and reproductive success should take into
account that while fatherhood may decrease T levels in both the
short and long term, once a father, higher T levels are positively
associated with number of children.

Supporting Information
ESM S1 Additional analyses on the full sample. (DOCX)
ESM S2 Additional analyses on sample of [35]. (DOCX)
ESM S3 Descriptive statistics for the male working sample
(n = 754) and the female working sample (n = 669). (DOC)
ESM S4 Predicted number of children in Poisson Model by Z
scores of (raw) testosterone for childed men (n = 704). (TIF)

Table 2. Parameter estimates (B), standard errors, Exp(B), and concomitant test statistics for overdispersed Poisson Models with
offspring count as dependent variable.

| Offspring count of men with at least one child |  |  |  |  |
|----------------------------------------------|----|----|----|----|
| Model 1                                      | B  | SE | Exp(B) | p  |
| log(testosterone) (pg/ml)                    | 0.243 | 0.113 | 1.275 | 0.032 |
| Model 2                                      | log(testosterone) (pg/ml) | 0.294 | 0.113 | 1.341 | 0.009 |
| (ΔAIC = 13.75; ΔBIC = 9.2) age (years)      | 0.011 | 0.003 | 1.011 | <.0001 |
| Model 3                                      | log(testosterone) (pg/l) | 0.293 | 0.112 | 1.341 | 0.009 |
| (ΔAIC = 1.74; ΔBIC = −11.81) age (years)    | 0.010 | 0.003 | 1.010 | 0.0002 |
| Education                                    | <High School | 0.175 | 0.066 | 1.191 | 0.008 |
| High School                                  | 0.125 | 0.052 | 1.133 | 0.015 |
| Voc./college/…                                | 0.076 | 0.051 | 1.079 | 0.14 |
| Bachelors or more                            | – | – | – | – |

For educational attainment 'Bachelors or more' was set as reference category.
doi:10.1371/journal.pone.0060018.t002

Table 3. Descriptive statistics for the male working sample.

| Parameter | Mean | SD  | Min  | Max  |
|-----------|------|-----|------|------|
| Age (years) | 42.5 | 12.5 | 18   | 70   |
| Education  | Voc./college/… | 0.125 | 0.052 | 1.133 | 0.015 |
| Income     | Median | 50,000 | 20,000 | 100,000 |
| BMI        | Mean   | 25.0 | 5.0  | 18.0 |

Table 4. Summary of Poisson Models with overdispersed variance.

| Parameter | B1 | B2 | B3 | B4 | B5 | B6 |
|-----------|----|----|----|----|----|----|
| Age (years) | 0.011 | 0.003 | 1.011 | <.0001 |
| Education  | <High School | 0.175 | 0.066 | 1.191 | 0.008 |
| High School | 0.125 | 0.052 | 1.133 | 0.015 |
| Voc./college/… | 0.076 | 0.051 | 1.079 | 0.14 |
| Bachelors or more | – | – | – | – |

ESM S1 Additional analyses on the full sample. (DOCX)
ESM S2 Additional analyses on sample of [35]. (DOCX)
ESM S3 Descriptive statistics for the male working sample
(n = 754) and the female working sample (n = 669). (DOC)
ESM S4 Predicted number of children in Poisson Model by Z
scores of (raw) testosterone for childed men (n = 704). (TIF)
Author Contributions
Conceived and designed the experiments: TVP KDC LvdM. Analyzed the data: TVP. Wrote the paper: TVP KDC LvdM.

References
1. Clutton-Brock TH (1991) The Evolution of Parental Care. Princeton, NJ: Princeton University Press.
2. Geary DC (2000) Evolution and proximate expression of human paternal investment. Psychological Bulletin 126: 53–77. doi:10.1037/0033-2909.126.1.5
3. Gray PB, Anderson KG (2010) Fatherhood: Evolution and human paternal behavior. Cambridge, MA: Harvard University Press.
4. Gettlert LT (2010) Direct Male Care and Hominin Evolution: Why Male–Child Interaction Is More Than a Nice Social Idea. American Anthropologist 112: 7–21. doi:10.1111/j.1543-1446.2009.01193.x
5. Wingfield JC, Hegner RE, Duffy JR AM, Ball GF (1990) The “challenge hypothesis”: theoretical implications for patterns of testosterone secretion, mating systems, and breeding strategies. American Naturalist 136: 829–846.
6. McGlothlin JW, Jacobs KM, Kettersson ED (2007) Natural variation in a testosterone-mediated trade-off between mating effort and parental effort. American Naturalist 170: 864–875. doi:10.1086/522838.
7. Archer J (2006) Testosterone and human aggression: an evaluation of the challenge hypothesis. Neuroscience & Biobehavioral Reviews 30: 319–345. doi:10.1016/j.neubiorev.2004.12.007.
8. Van der Meij L, Buunk AP, Van de Sande JP, Salvador A (2008) The presence of a woman increases testosterone in aggressive dominant men. Hormones and Behavior 54: 640–644. doi:10.1016/j.yhbeh.2008.07.001.
9. Ellison PT (2003) Energetics and reproductive effort. American Journal of Human Biology 15: 342–351. doi:10.1002/ajhb.10152.
10. Bribiescas RG, Ellison PT, Gray PB (2012) Male Life History, Reproductive Effort, and the Evolution of the Genus Homo. Current Anthropology 53: 8424–8455. doi:10.1086/675755.
11. Booth A, Dabbs Jr JM (1993) Testosterone and men’s marriages. Social Forces 72: 463–477. doi:10.2307/2578057.
12. Mazzu A, Michalek J (1998) Marriage, divorce, and male testosterone. Social Forces 77: 315–330. doi:10.1353/sof.2005.0001.
13. Gray PB, Kahlenberg SM, Barrett ES, Lipson SF, Ellison PT (2002) Marriage and fatherhood are associated with lower testosterone in males. Evolution and Human Behavior 23: 193–201. doi:10.1016/S1090-5138(01)00015-5.
14. Gray PB, Chapman JF, Burnham TC, McIntyre MH, Lipson SF, et al. (2004) Human male pair bonding and testosterone. Human Nature 15: 119–139. doi:10.10112/j1543-1446.2010-166-6.
15. Burnham TC, Chapman JF, Gray PB, McIntyre MH, Lipson SF, et al. (2003) Men in committed, romantic relationships have lower testosterone. Hormones and Behavior 44: 119–122. doi:10.1016/S0047-2075(03)00523-9.
16. Sakaguchi K, Oki M, Homma S, Hasegawa T (2006) Influence of relationship status and personality traits on salivary testosterone among Japanese men. Personality and Individual Differences 41: 1077–1087. doi:10.1016/j.paid.2006.07.013.
17. Gettlert LT, McDade TW, Feranil AB, Kuzawa CW (2011) Longitudinal evidence that fatherhood decreases testosterone in human males. Evolution and Human Behavior 32: 202–208. doi:10.1016/j.ybeh.2011.07.045.
18. Van der Meij L, Almeida M, Buunk AP, Fasceott TW, Salvador A (2012) Men with elevated testosterone levels show more affiliative behaviours during interactions with women. Proceedings of the Royal Society B: Biological Sciences 279: 202–208. doi:10.1098/rspb.2011.0764.
19. Bogaert AF, Fisher WA (1995) Predictors of university men’s number of sexual partners. Journal of Sex Research 32: 119–138. doi:10.1080/00224490959351762.
20. Peters M, Simmons LW, Rhodes G (2008) Testosterone is associated with mating success but not attractiveness or masculinity in human males. Animal Behaviour 76: 297–303. doi:10.1016/j.anbehav.2008.02.008.
21. Pollet T V, Van der Meij L, Cobey KD, Buunk AP (2011) Testosterone levels and their associations with lifetime number of opposite sex partners and remarriage in a large sample of American elderly men and women. Hormones and Behavior 60: 72–77. doi:10.1016/j.yhbeh.2011.03.005.
22. Van Anders SM, Watson N V (2006) Relationship status and testosterone in North American heterosexual and non-heterosexual men and women: Cross-sectional and longitudinal data. Psychoneuroendocrinology 31: 713–723. doi:10.1016/j.psyneuen.2006.01.008.
23. Barrett ES, Tran V, Thurston S, Jasienska G, Furguson A, et al. (2013) Marriage and motherhood are associated with lower testosterone concentrations in women. Hormones and Behavior 63: 72–79. doi:10.1016/j.yhbeh.2012.10.012.
24. Kuzawa CW, Gettlert LT, Huang Y, McDade TW (2010) Mothers have lower testosterone than non-mothers: Evidence from the Philippines. Hormones and Behavior 57: 441–447. doi:10.1016/j.yhbeh.2010.01.014.
25. Waite LJ, Laumann EO, Levinson W, Lindau ST, McClintock MK, et al. (2010) National Social Life, Health, and Aging Project (NSHAP). Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor]; 7–28.
26. NORC (n.d.) National Social Life, Health, and Aging Project (NSHAP). NSHAP website. Available: http://www.norc.org/Research/Projects/Pages/national-social-life-health-and-aging-project.aspx. Accessed 2013 March 5.
27. Ellis L, Nyborg H (1992) Racial/ethnic variations in male testosterone levels: A probable contributor to group differences in health. Steroids 57: 72–75. doi:10.1016/0039-128X(92)90332-5.
28. Abma JC, Chandra A, Peterson L, Mosher W (1998) Fertility, family planning, and women’s health: new data from the 1995 National Survey of Family Growth. DIANE Publishing.
29. Gurak DT (1978) Sources of Ethnic Fertility Differences: An Examination of Five Minority Groups. Social Science Quarterly 59: 295–310.
30. Hogan DP, Sun R, Cornwell GT (2000) Sexual and fertility behaviors of American females aged 13–19 years: 1985, 1990, and 1995. American Journal of Public Health 90: 1421–1425. doi:10.2105/AJPH.90.9.1421.
31. Salimetrics website. Available: http://www.salimetrics.com/assets/documents/products-and-services/salivaryassays/Testo-R insert 2–20.pdf. Accessed 2011 March 20.
32. Tenover JP, Matsutomo AM, Clifton DK, Bremer VJ (1980) Age-related alterations in the circadian rhythms of pulsatile luteinizing hormone and testosterone secretion in healthy men. Journal of Gerontology 35: M163–M169. doi:10.1093/gerona/35.5.M163.
33. Bremer VJ, Vitale M V, Preece PN (1983) Loss of circadian rhythmicity in blood testosterone levels with aging in normal men. Journal of Clinical Endocrinology & Metabolism 56: 1278–1281. doi:10.1210/jcem-56-6.1278.
34. Gardner W, Mulvey EP, Shaw EC (1995) Regression analyses of counts and product–service combinations: The effect of overdispersion. Psychological Bulletin 118: 392–401. doi:10.1037/0033-2909.118.3.392.
35. Berk R, MacDonald JM (2008) Overdispersion and Poisson regression. Journal of Quantitative Criminology 24: 269–284. doi:10.1007/s10945-008-9048-4.
50. Akaike H (1974) A new look at the statistical model identification. IEEE Transactions on Automatic Control 19: 716–723. doi:10.1109/TAC.1974.1100705.
51. Raftery AE (1996) Approximate Bayes factors and accounting for model uncertainty in generalised linear models. Biometrika 83: 251–266. doi:10.1093/biomet/83.2.251.
52. Burnham KP, Anderson DR (2002) Model selection and multimodel inference: a practical information-theoretic approach. New York, NY: Springer.
53. Burnham KP, Anderson DR (2004) Multimodel inference. Sociological Methods & Research 33: 261–304. doi:10.1177/0049124104268664.
54. Schwarz G (1978) Estimating the dimension of a model. The Annals of Statistics 6: 461–464. doi:10.1214/aos/1176344136.
55. Bribiescas RG (2010) An evolutionary and life history perspective on human male reproductive senescence. Annals of the New York Academy of Sciences 1204: 54–64. Available: http://dx.doi.org/10.1111/j.1749-6632.2010.05524.x.
56. McLachlan RI, O’Donnell L, Meachem SJ, Stanton PG, De Kretser DM, et al. (2002) Identification of specific sites of hormonal regulation in spermatogenesis in rats, monkeys, and man. Recent Progress in Hormone Research 57: 149–179. doi:10.1210/rp.57.1.149.
57. Stewart TM, Liu DY, Garrett C, Jørgensen N, Brown EH, et al. (2009) Associations between andrological measures, hormones and semen quality in fertile Australian men: inverse relationship between obesity and sperm output. Human Reproduction 24: 1561–1568. doi:10.1093/humrep/dep075.
58. Bribiescas RG (2001) Reproductive ecology and life history of the human male. American Journal of Physical Anthropology 116: 148–176. Available: http://dx.doi.org/10.1002/ajpa.10025.
59. Davison SL, Bell R, Donath S, Montalto JG, Davis SR (2005) Androgen Levels in Adult Females: Changes with Age, Menopause, and Oophorectomy. Journal of Clinical Endocrinology & Metabolism 90 : 3847–3853. Available: http://jcem.endojournals.org/content/90/7/3847.abstract.
60. Falk RT, Fears TR, Hoover RN, Pike MC, Wu AH, et al. (2002) Does place of birth influence endogenous hormone levels in Asian-American women? British Journal of Cancer 87: 54–60. doi:10.1038/sj.bjc.6600339.
61. Pollard TM, Unwin NC, Fischbacher CM, Chamley JK (2006) Sex hormone-binding globulin and androgen levels in immigrant and British-born premenopausal British Pakistani women: Evidence of early life influences? American Journal of Human Biology 18: 741–747. Available: http://dx.doi.org/10.1002/ajhb.20526.
62. Harman SM, Metter EJ, Tobin JD, Pearson J, Blackman MR (2001) Longitudinal effects of aging on serum total and free testosterone levels in healthy men. Journal of Clinical Endocrinology & Metabolism 86: 724–731. doi:10.1210/jc.86.2.724.