Physiology & Behavior 119 (2013) 110–114

Contents lists available at SciVerse ScienceDirect

Physiology & Behavior

journal homepage: www.elsevier.com/locate/phb

Serum testosterone levels in males are not associated with entrepreneurial behavior in two independent observational studies

Matthijs J.H.M. van der Loos [a,b,*], Robin Haring [c], Cornelius A. Rietveld [a,b], Sebastian E. Baumeister [d], Patrick J.F. Groenen [e], Albert Hofman [b], Frank H. de Jong [f], Philipp D. Koellinger [a,b], Thomas Kohlmann [d], Matthias A. Nauck [c], Fernando Rivadeneira [b,f], André G. Uitterlinden [b,f], Frank J.A. van Rooij [b], Henri Wallaschofski [c], A. Roy Thurik [a,g,h]

[a] Department of Applied Economics, Erasmus School of Economics, Erasmus University Rotterdam, Rotterdam, The Netherlands
[b] Department of Epidemiology, Erasmus Medical Center, Rotterdam, The Netherlands
[c] Institute of Clinical Chemistry and Laboratory Medicine, University Medicine Greifswald, Greifswald, Germany
[d] Institute for Community Medicine, University Medicine Greifswald, Greifswald, Germany
[e] Econometric Institute, Erasmus School of Economics, Erasmus University Rotterdam, Rotterdam, The Netherlands
[f] Department of Internal Medicine, Erasmus Medical Center, Rotterdam, The Netherlands
[g] Panteia, Zoetermeer, The Netherlands
[h] GSCM-Montpellier Business School, Montpellier, France

HIGHLIGHTS

- Current research into the relationship between testosterone and self-employment is limited.
- We investigated this relationship using two large, independent, population-based, observational studies.
- Measures of serum bioactive as well as total testosterone were not associated with self-employment.

ARTICLE INFO

Article history:
Received 8 March 2013
Accepted 4 June 2013
Available online 12 June 2013

Keywords:
Entrepreneurship
Self-employment
Serum testosterone
Free testosterone
Non-sex hormone-binding globulin-bound testosterone
Sex hormone-binding globulin

ABSTRACT

Previous research has suggested a positive association between testosterone (T) and entrepreneurial behavior in males. However, this evidence was found in a study with a small sample size and has not been replicated. In the present study, we aimed to verify this association using two large, independent, population-based samples of males. We tested the association of T with entrepreneurial behavior, operationalized as self-employment, using data from the Rotterdam Study ($N = 587$) and the Study of Health in Pomerania ($N = 1697$). Total testosterone (TT) and sex hormone-binding globulin (SHBG) were measured in the serum. Free testosterone (FT), non-SHBG-bound T (non-SHBG-T), and the TT/SHBG ratio were calculated and used as measures of bioactive serum T, in addition to TT adjusted for SHBG. Using logistic regression models, we found no significant associations between any of the serum T measures and self-employment in either of the samples. To our knowledge, this is the first large-scale study on the relationship between serum T and entrepreneurial behavior.

1. Introduction

Entrepreneurial behavior is an important element and a driving force behind dynamic changes in modern economies [1]. Empirical evidence suggests that important economic stimuli ensue from entrepreneurship [2–4]. Thus, understanding the motivations underlying entrepreneurial behavior is highly relevant. Individual socio-demographic characteristics such as age, sex, and educational attainment have traditionally been a major research focus [5], but recently, increased testosterone (T) levels have been suggested to be a biological predisposing factor for entrepreneurial behavior.

Specifically, White et al. [6] observed that many of the features that characterize entrepreneurs correlate with T. For example, risk-taking behavior is a much-debated feature of entrepreneurship [7,8] and has been shown to be associated with T [9–14]. Based on such relationships, White et al. [6] argued that higher T levels may induce entrepreneurial behavior, and these authors developed a theoretical basis for this relationship by drawing upon evolutionary psychology theory. They hypothesized that individuals with higher T levels are more likely to engage in new venture

* Corresponding author at: Department of Applied Economics, Erasmus School of Economics, Erasmus University Rotterdam, P.O. Box 1738, 3000 DR, Rotterdam, The Netherlands. Tel.: +31 104081373; fax: +31 104089141.
E-mail address: mvanderloos@ese.eur.nl (M.J.H.M. van der Loos).

0031-9384/$ – see front matter
http://dx.doi.org/10.1016/j.physbeh.2013.06.003

creation, the authors' measure of entrepreneurship, and that this relationship is partially mediated by an individual's risk propensity. White et al. [6] found evidence for their hypothesis using a salivary T measure in a sample of 110 male North American MBA students. However, this study was limited by a small sample size and has not been replicated. Although there is some evidence to suggest that the 2D:4D digit ratio, a hypothesized proxy for prenatal and adult T levels [15,16], and entrepreneurial behavior are associated [17–19], there is contradictory evidence about the validity of this digit ratio as a proxy for T (see Ref. [20] for the most recent discussion). The precise role of T in entrepreneurial behavior therefore remains unknown.

Thus, the aim of our study was to evaluate the relationship between entrepreneurship, operationalized as self-employment, in a much larger sample of males than previously used. In particular, we utilized two large, independent, population-based samples of males and measured their serum T levels, in contrast to the salivary T measure used by White et al. [6]. In the serum, T is mainly bound to sex hormone-binding globulin (SHBG) and albumin, leaving only a small fraction of T unbound or free. By binding to T, SHBG prohibits T from diffusing from the bloodstream into target tissue cells and performing its biological function. Hence, free testosterone (FT) is generally regarded as bioactive. It is unclear if albumin-bound T is also bioactive [21,22]. In our analyses, we used FT and non-SHBG-bound T (albumin-bound and free) as measures of bioactive T, in addition to the total T (TT)/SHBG ratio and TT adjusted for SHBG. Our measures are similar to the salivary T measure used by White et al. [6] because salivary T reflects the part of serum T that is free [23]. For completeness, we also tested for an association between TT and self-employment. Based on previous findings, we hypothesized that there is a positive association between the serum T measures and self-employment.

2. Materials and methods

2.1. Participants

All of the participants provided written informed consent, and the study was approved by the medical ethics committee of the Erasmus Medical Center and the local Ethics Committee of the University of Greifswald.

We used cross-sectional data from two population-based cohorts: the Rotterdam Study (RS) and the Study of Health in Pomerania (SHIP). The RS is a large, population-based cohort study of the elderly that has been ongoing since 1990 in the city of Rotterdam in the Netherlands [24,25]. From 1990 to 1993, 10,215 inhabitants aged 55 and over from the Ommoord district were invited to participate, and 7983 (response 78%) took part in the baseline examination, including 3105 males. In addition to the original cohort used here (RS-I), there are two other cohorts included in the Rotterdam Study (RS-II and RS-III), but T was not measured in these cohorts. We excluded those participants who used sex hormones (ATC code G03), testosterone 5a-reductase inhibitors (ATC code G04CB), sex hormone antagonists (ATC code L02B), or anabolic steroids (ATC code A14A) because of the effects of these drugs on the serum T level. Males with missing data on hormone levels, self-employment, or covariates were also excluded, leaving 589 males from the RS in our sample.

The SHIP is a population-based cohort study ongoing in West Pomerania, a region in northeastern Germany [26]. A two-stage cluster sampling method was adopted from the WHO MONICA Project (Augsburg, Germany) to select a sample of 7008 individuals from the entire population of 212,157 people living in the area using the population registration offices, where all German inhabitants are registered. Individuals without German citizenship and those who did not reside in the study area were excluded. The final sample comprised 4308 participants at baseline (response 69%), including 2116 males. We excluded users of sex hormones (ATC code G03), testosterone 5a-reductase inhibitors (ATC code G04CB), sex hormone antagonists (ATC code L02B), or anabolic steroids (ATC code A14A). After excluding males with missing data on self-employment, hormone levels, or covariates, 1697 males from the SHIP were available for the analyses.

2.2. Hormone measurements

The serum TT and sex hormone-binding globulin (SHBG) levels were measured using coated tube (T) or double antibody (SHBG) radioimmunoassays (Diagnostic Systems Laboratories, Inc., Webster, TX) in the RS and using competitive chemiluminescent enzyme immunoassays (Siemens Immulite 2500 Total Testosterone, ref. L5KTW, lot 110; Immulite 2550 SHBG ref. L5KSH, lot 119; Siemens Healthcare Medical Diagnostics, Bad Nauheim, Germany) in the SHIP. Further details have been described previously [27–29].

As measures of bioactive T, we used FT, non-SHBG-bound T (non-SHBG-T), the TT/SHBG ratio, and TT adjusted for SHBG. Serum FT and non-SHBG-T levels were calculated according to the method of Södergard et al. [30], using previously described equations [31] assuming a fixed albumin level of 40 g/l.

2.3. Self-employment and covariate measures

At baseline, participants from the RS were interviewed at home and asked for their complete work-life histories. The participants' occupations and employment status (employed, self-employed, or a collaborating family member) for each occupation were recorded. Based on this information, we were able to identify individuals who were self-employed at some point during their working careers and individuals who had not been self-employed. Individuals who had never had a job and individuals with an incomplete work-life history except those who were classified as self-employed at least once were excluded from our study. The rationale for excluding these individuals is that individuals with incomplete work-life histories could have been self-employed at least once in the past, which would make it impossible to interpret the coefficient for self-employment.

In the SHIP, participants were asked about their current or last occupational status using questionnaires. We coded individuals as self-employed if they reported that they were farmers with more than 10 hectares of property (2.5% of the self-employed), university graduates with a liberal profession, e.g., physician, lawyer, or tax accountant (8.6% of the self-employed), or self-employed in business, craft, or the tertiary sector (88.9% of the self-employed). The self-employment rate was lower in the SHIP than in the RS, in agreement with the fact that the SHIP is located in the former German Democratic Republic, where self-employment was systematically discouraged [32].

Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. In the RS, weight and height were measured during the research facility visit while participants were wearing indoor clothing and no shoes. SHIP participants were wearing lightweight clothing and no shoes during height and weight measurements. Current smoking status was assessed using a computerized questionnaire during the home interview in the RS and using computer-assisted personal interviews in the SHIP. To harmonize educational attainment measures across the RS and the SHIP, we first transformed the study-specific measures to an internationally comparable measure of educational attainment according to UNESCO's International Standard Classification of Education (ISCED) scale [33]. The ISCED levels were then converted to US years of schooling equivalents.

2.4. Statistical analyses

Categorical data are reported as percentages, and continuous data are represented as the mean together with the standard deviation. Differences between groups were tested using Pearson's χ^2 tests for categorical data and *t*-tests for continuous data.