Economics Working Paper Series

Faculty of Business, Economics and Law, AUT

In and Out of Unemployment – Labour Market Transitions and the Role of Testosterone

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2020/13

IN AND OUT OF UNEMPLOYMENT –LABOUR MARKET TRANSITIONS AND THE ROLE OF TESTOSTERONE

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Abstract

Biological processes have provided new insights into diverging labour market trajectories. This paper uses population variation in testosterone levels to explain transition probabilities into and out of unemployment. We examine labour market transitions for 2,004 initially employed and 111 initially unemployed British men from the UK Household Longitudinal Study ("Understanding Society") between 2009 and 2015. We address the endogeneity of testosterone levels by using genetic variation as instrumental variables (Mendelian Randomization). We find that for both initially unemployed men as well as initially employed men, higher testosterone levels reduce the risk of unemployment. Based on previous studies and descriptive evidence, we argue that these effects are likely driven by differences in cognitive and non-cognitive skills as well as job search behaviour of men with higher testosterone levels. Our findings suggest that latent biological processes can affect job search behaviour and labour market outcomes without necessarily relating to illness and disability.

Keywords: labour market dynamics, unemployment, testosterone

JEL classification: I10, J64, C23

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Funding:

Kanabar acknowledges generous supported from the University of Bath International Research Funding Scheme (Developing Networks in Europe). Grant ref:VB-SP3ARK.

Declarations of Interest:

The authors declare no conflicts of interest

Acknowledgements:

We would like to thank Amanda Hughes and Meena Kumari for providing access to the polygenic score, and Juliane Hennecke, Allan Mazur, Nicholas Papageorge, and Steven Pudney for their helpful comments and suggestions on an earlier draft of the paper.

These data are from Understanding Society: The UK Household Longitudinal Study, which is led by the Institute for Social and Economic Research at the University of Essex and funded by the Economic and Social Research Council (Grant Number: ES/M008592/1). The data were collected by NatCen and the genome wide scan data were analysed by the Wellcome Trust Sanger Institute. Information on how to access the data can be found on the Understanding Society website https://www.understandingsociety.ac.uk/

Data governance was provided by the METADAC data access committee, funded by ESRC, Wellcome, and MRC. (2015-2018: Grant Number MR/N01104X/1 2018-2020: Grant Number ES/S008349/1).

Understanding Society is an initiative funded by the Economic and Social Research Council and various Government Departments, with scientific leadership by the Institute for Social and Economic Research, University of Essex, and survey delivery by NatCen Social Research and Kantar Public. The research data are distributed by the UK Data Service.

1 Introduction

'Joblessness leaves permanent scars on individuals' (Arulampalam, 2001, p. 585), partly because unemployed individuals might be perceived (and might perceive themselves) as violating a social norm. On the other hand, it can also be a rational decision to remain unemployed for a period to hold out for a better job offer and improve the job match. The economic literature has shown that various factors explain why individuals become unemployed or stay in unemployment. However, the focus has been on observable factors, such as individual and household characteristics or the past unemployment experience and duration (see, e.g., Gregg, 2001). More recent evidence points to personality traits and non-cognitive skills as influential factors of job search behaviour and unemployment duration. Studies have investigated, e.g., the locus of control (Caliendo et al., 2015; Heckman et al., 2006; Schurer, 2017), impatience (DellaVigna and Paserman, 2005), the Big 5 personality traits (Viinikainen and Kokko, 2012), or self-efficacy and interpersonal skills (Uysal and Pohlmeier, 2011).

Hormones have been linked to a number of non-cognitive skills and personality aspects. In particular, testosterone is prominently linked to risk-attitude and aggression (Dabbs, 1992; Dabbs et al., 2001; Hughes and Kumari, 2019), but also to skills such as motivation, pro-social behaviour, persistence, or numerical ability (Apicella et al., 2008; Carré and McCormick, 2008; Dabbs et al., 2001; Welker and Carré, 2015). Likely related to these attributes, testosterone has also repeatedly been found to predict men's labour market performance (Dreher et al., 2016; Gielen et al., 2016; Nye et al., 2017). Moreover, testosterone also seems to affect occupational choices (Dabbs, 1992; Greene et al., 2014). Yet, surprisingly testosterone has not been investigated as an explanatory factor of unemployment, something we address in this paper.

We investigate whether differences in serum testosterone levels of men can explain transitions in and out of unemployment. We use data from *Understanding Society (UKHLS),* a longitudinal survey covering about 40,000 households from the United Kingdom, which also holds a range of biomarker data, including the circulating testosterone level. We examine two samples of initially employed or initially unemployed men aged 25 to 60, and we standardise their testosterone levels for age and time the survey data was collected.

Taking advantage of the longitudinal nature of the data, we examine the likelihood for unemployed men to exit unemployment as well as the risk of entering unemployment for employed men within the following year. Following Hughes and Kumari (2019), we also use a polygenic score derived from three genetic markers as an instrument for testosterone levels in a Mendelian Randomization approach to examine how sensitive our results are to potential endogeneity.

We contribute to the literature by providing novel evidence on latent biological mechanisms which affect labour market trajectories. Previous studies have only considered inflammation markers in relation to unemployment but not hormones such as testosterone (Sumner et al., 2020). Moreover, unlike

previous studies, we examine actual testosterone levels measured in a recent blood sample rather than 2D:4D ratio, which is a prominent marker for prenatal exposure to testosterone (see, e.g., Gielen et al., 2016). The closest study to ours is Hughes and Kumari (2019), who examined the impact of testosterone on risk tolerance, gross earnings, household net income, and socio-economic status. In contrast to our study, they only considered the likelihood of being in work at a single point in time, whereas we consider labour market transitions.

Findings from our preferred regression specification indicate that the risk of remaining unemployed significantly declines in testosterone level for unemployed men. In contrast, testosterone has no significant effect on the unemployment risk of employed men. However, the Mendelian Randomisation analysis suggests that serum testosterone levels might be endogenous, and that testosterone reduces the risk of unemployment in both samples.

Cognitive and non-cognitive skills, such as numerical skills or logical reasoning, might partly explain these findings as these are associated with high testosterone levels. In line with previous studies, our descriptive evidence shows that men with high testosterone levels indeed performed better in these areas. In addition, we find suggestive evidence that individuals with higher testosterone search differently for a job.

Our findings highlight how latent biological processes beyond illness and disease affect labour market outcomes. For example, when designing job search assistance programs, policymakers must be aware that biological mechanisms can drive differences in job search behaviour. Thus, due to their inherent skills, some individuals might require specific forms of assistance to thrive - for example, individual training rather than group sessions. This study contributes to our understanding of such mechanisms by providing comprehensive evidence on the role of testosterone.

The rest of this paper is set out as follows. Section 2 reviews the literature on biomarkers, and based on this literature we discuss how testosterone could affect labour market transitions. Section 3 presents our data and Section 4 outlines our empirical estimation strategy. Section 5 contains descriptive statistics. Section 6 documents the results from our regression specifications. Section 7 discusses further possible mechanisms and descriptive evidence for these potential pathways. Section 8 concludes.

2 Testosterone and the labour market

2.1 Existing literature

Testosterone has been related to different forms of health issues, e.g., cardiovascular disease (Elagizi et al., 2018), but the evidence is inconclusive, and the causal pathways are not fully understood (Bann et al., 2015; Hughes and Kumari, 2019). Evidence suggests that among men, testosterone seems to affect risky health behaviours and, thus, different forms of health hazards (Booth et al., 1999).

Testosterone also plays a role for demographic outcomes, such as fertility, divorce, and mating (e.g., Bütikofer et al., 2019), fitness and sport (e.g., Hsu et al., 2015), but also for labour market outcomes (e.g., Coates et al., 2009; Dabbs, 1992; Dabbs Jr. et al., 1990; Parslow et al., 2019).[5] For example, in a twin study on Dutch men, more prolonged prenatal testosterone exposure led to higher earnings during working life (Gielen et al., 2016). [6] Other studies found education to be lower among people with low testosterone levels (Bann et al., 2015; Nye et al., 2017). Coates and Herbert (2008) followed the daily business of 300 traders in London and found that high testosterone levels lead to higher profits on that day. Testosterone also seems to affect the choice of occupation. Low testosterone individuals choose more people-oriented jobs, whereas high testosterone individuals choose more things-oriented jobs (Dabbs Jr. et al., 1990; Hell and Päßler, 2011; Nye and Orel, 2015).[7] Typical jobs that have been related to high testosterone are sportsmen, sales men, actors, or politicians (Dabbs Jr. et al., 1990). The evidence is not conclusive, though. A more robust finding is that individuals with high testosterone levels have a higher probability to be self-employed (Greene et al., 2014; Nicolaou et al., 2017; Sapienza et al., 2009).

The findings discussed above are usually attributed to non-cognitive skills and individual characteristics associated with high testosterone levels. Typical characteristics that have been stressed in the literature are, among others, being independent, self-centred, adventurous, achievement-oriented, and focused on personal goals (Greene et al., 2014). Further, high testosterone is associated with risk-taking (Apicella et al., 2008; Coates and Herbert, 2008; Hughes and Kumari, 2019; Stenstrom et al., 2011), dominant behaviour, and aggression (Archer, 2006; Chance et al., 2000; Dabbs, 1992; Dabbs et al., 2001; Schaal et al., 1996), but also status-enhancing pro-social behaviour.[8] For example, Dreher et al. (2016) injected testosterone or a placebo to 40 young men and found that in an economic bargaining game, treated individuals were indeed more aggressive towards others. However, at the same time, they were also more generous when it promoted social status. Similarly, individuals with high testosterone levels show more initiative in forming friendships and are, therefore, able to build up more extensive social networks (Booth et al., 2006; Cheng et al., 2013). In other game studies, men with high testosterone levels were more willing to engage in competitive tasks (Carré and McCormick, 2008), and they showed more persistence in solving an undoable task (Welker and Carré, 2015).

Cognitive abilities have also been related to testosterone. While early work reported that young boys

[5] While testosterone is present in both sexes, most of the experimental studies in the literature have focused on men. Important exceptions looked at both sexes (Dabbs et al., 2001; Gielen et al., 2016; Nye et al., 2017; Sapienza et al., 2009) or exclusively at women (Bütikofer et al., 2019; Parslow et al., 2019).

[6] Among women, high testosterone levels are expected to be associated with higher earnings as well, as women with higher testosterone levels tend to work in male-dominated occupations, which tend to be better paid. However, recent empirical evidence found the opposite or no effect (Bütikofer et al., 2019; Gielen et al., 2016; Nye et al., 2017).

[7] Women that have higher testosterone levels tend to choose jobs that are male-dominated, whereas women with low levels choose more female-dominated jobs (Nye and Orel, 2015). This observation has been used to explain parts of the gender pay gap (e.g., Gielen et al., 2016).

[8] The effect of testosterone on prosocial status-promoting behaviour and risk has been found to be moderated by cortisol (e.g., Mehta and Prasad, 2015).

with high testosterone levels lack intelligence (Chance et al., 2000; Dabbs, 1992), more recent work showed that individuals with high testosterone levels have higher numeric capabilities and thus perform better in computer science or related occupations (Brookes et al., 2007; Brosnan et al., 2011). Similarly, individuals with more prolonged prenatal exposure to testosterone performed better in the cognitive reflection test (Bosch-Domènech et al., 2014), a test which measures the tendency to override an intuitive incorrect answer, and which has therefore been used as a measure of reflection in decision making (Frederick, 2005). Finally, a series of studies showed that people with high testosterone levels perform better in face-to-face situations (Dabbs et al., 1997; Mazur, 1985). For example, Dabbs (2001) interviewed and filmed male college students and found that individuals with high testosterone levels appeared more forward, independent, focused, restless, and oriented toward action.

2.2 Testosterone and employment transitions

There are multiple pathways of how testosterone might relate to unemployment. We focus on differences in job search behaviour and self-selection by occupational choice while distinguishing between entry into unemployment and exit from unemployment.

As noted above, high testosterone levels are associated with aggression (in the broader sense), which includes competition-seeking and dominant behaviour (Archer, 2006; Chance et al., 2000), but also pro-social behaviour (Dreher et al., 2016). If pro-social behaviour associated with higher testosterone levels leads to larger social networks, then these networks might constitute an essential resource for job search (Ponzi et al., 2016). Moreover, job search in general and assessment centres or job interviews in particular might favour competitive dominant and pro-social individuals. Thus, individuals with high testosterone might invest more effort into their job search since adopting the required behaviour comes more naturally (Dabbs et al., 2001, 1997) and exert less mental strain than it might for individuals with low testosterone. For similar reasons, individuals with high testosterone might perform better in such situations and might thus be more likely to receive a job offer. Yet, testosterone might also affect individuals' likelihood to accept a job offer. Individuals with low testosterone, who are less willing to take risks might accept a job offer earlier. In contrast, high testosterone individuals might be more inclined to take a risk and look for a better position. This is in line with the evidence that individuals with a higher testosterone level are more reflective in the decision-making process (Bosch-Domènech et al., 2014). Re-employment, therefore, would take longer for individuals with high testosterone but might result in a better job match. Conversely, high testosterone individuals, worried about their social status, might be more inclined to take first job offers to move out of an economically disadvantaged position due to the perceived social stigma of unemployment.

For individuals in employment, once employers learn about their employees' productivity, competition-seeking and dominant behaviour may become less critical. To some extent, such behaviour might even

be considered detrimental, e.g., for the performance in teams. Hence, individuals with high testosterone levels may be at an increased risk of entering unemployment compared to individuals with normal testosterone levels.

In terms of occupational choice, workers with high testosterone levels might select into jobs that are perceived as offering greater rewards at higher risks. For example, positions with performance-based remuneration and where redundancies are more common, e.g., in sales or self-employment. Besides, higher numeric capabilities associated with high testosterone levels (Brookes et al., 2007; Brosnan et al., 2011) would also imply a selection into certain occupations or sectors. Individuals with low testosterone tend to be more risk-averse and might prefer jobs that offer more stability (e.g., in the public sector). Such occupational sorting would imply that high testosterone individuals are more likely to face unemployment but are able to find re-employment relatively quickly. In contrast, individuals with low testosterone are less likely to lose their job but stay longer in unemployment if they become unemployed.

In summary, the existing evidence suggests that testosterone might affect transitions both in and out of unemployment, but the direction of the effect is ambiguous, and it may differ for exits and entries into unemployment.

3 Data

The UK Household Longitudinal Study *Understanding Society* is one of the few surveys available that collects both data on testosterone levels (among other biomarkers) as well as annual longitudinal data on individual's and household's characteristics. *Understanding Society* is the successor of the British Household Panel Survey (BHPS), which started in 2009, and at the time of writing 9 waves of data are available. With approximately 40,000 households (at Wave 1) in the United Kingdom, it collects a range of individual and household-related information that also enables the researcher to trace labour market trajectories. Approximately five months after their Wave 2 or Wave 3 (2010-2013) mainstage interview, adult participants received a health assessment visit from a registered nurse ('Health and biomarkers survey').[9] A range of bio-medical measures was collected from over 20,000 adults, including testosterone levels.

[9] The nurse health visit was conducted among adult survey participants from the General Population Sample (GPS) which consists of households in the UK and BHPS sample only. The nurse visit took place after wave 2 (May 2010-July 2012) for those individuals in the GPS and after wave 3 (June 2011-July 2012) for BHPS sample respondents.

3.1 Health and biomarkers Survey

To be eligible for a nurse interview survey, respondents must have completed a full face-to-face interview in the most recent mainstage wave, lived in Great Britain, completed their interview in English, and, for women, were not pregnant. Among those eligible, approximately 20,700 (57%) took part, of which 13,107 (68.5%) had at least one biomarker which was successfully obtained and processed (Benzeval et al., 2014). During the nurse visit, blood samples were taken to extract a range of biomarker data, including measures of growth hormones (testosterone, DHEA's, IGF-1). Serum testosterone, the specific biomarker of interest for this study, was measured using an electrochemiluminescent immunoassay on the Roche Modular E170 analyser.

Testosterone levels show wide variation among men and are considered within a normal range between 9-25 nmol/L. Testosterone varies by time of day, such that values in the morning are higher than those found in the afternoon or evening (See **Table 1**). The level of testosterone also declines in age (See **Figure 1**). Apart from time and age, differences in testosterone levels are expected to originate from prenatal development, particularly in-utero exposure to testosterone. The sex difference in testosterone is almost non-existent before puberty but up to 20 times higher for men thereafter (e.g., Handelsmann et al. 2018). However, where the variation for testosterone levels among men comes from is not entirely clear. There is evidence from mice that maternal stress alters plasma testosterone levels in fetal males (Ward and Weisz, 1980). Similarly, testosterone levels have been found to interrelate with other hormones like cortisol and hence to stress, but evidence for humans is scarce (Braude et al. 1999). In the Health and biomarkers Survey, there are 3,597 men with a plausible level of testosterone in the age range 25 to 64 who had their interview started between 8 am and 8 pm.[10]

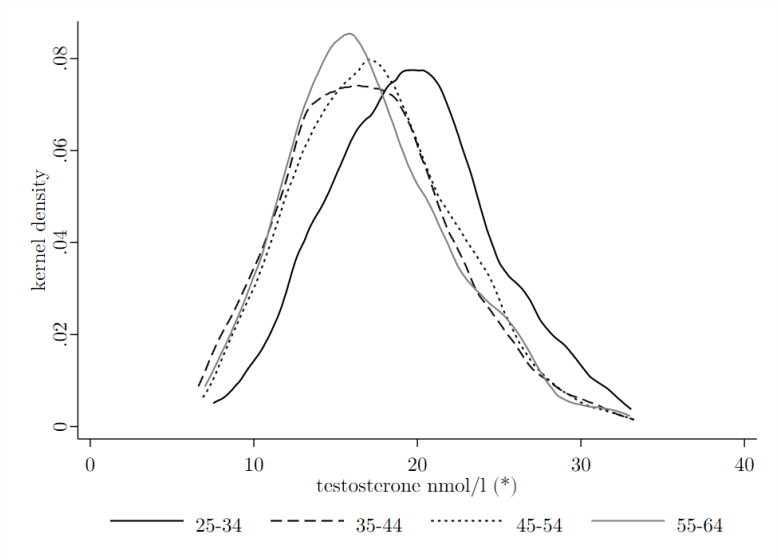
[10] The number of individuals having their interview outside that time window is negligible.

Table 1: Level of testosterone (nmol/l) and interview time

The start time of the interview (hour)	Testosterone (nmol/l)		
	Mean	Std Dev	*N*
8	17.30	5.92	16
9	17.73	5.84	154
10	17.82	5.21	367
11	17.14	5.21	303
12	17.08	5.29	194
13	15.14	5.14	175
14	15.44	5.27	208
15	14.39	5.06	223
16	14.55	5.10	275
17	14.80	4.79	350
18	14.36	4.85	584
19	13.78	4.78	594
20	13.09	4.47	154

Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. $N = 3{,}597$ men with a positive level of testosterone in the age range 20 to 64 who had their interview started between 8 am and 8 pm.

Figure 1: Level of testosterone (nmol/l) and age



Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. $N = 3{,}597$ men with a positive level of testosterone in the age range 25 to 64 who had their interview started between 8 am and 8 pm. (*) showing the level of testosterone (nmol/l) corrected by the time of the nurse visit.

3.2 Genetic data

We draw on genetic data collected during the Health and Biomarker Survey to assess the robustness of our findings, in particular with respect to reverse causality. Access to the data was granted via METADAC (Murtagh et al., 2018). Specifically, we investigate whether genetic variants that partly explain the variance of serum testosterone affect labour market dynamics in a way that is consistent with

our main findings. This method, which uses genetic markers as so-called Instrumental Variables (IV) is known as Mendelian Randomisation (MR) (Burgess and Thompson, 2015) and is outlined in section 4.4.

Individual's genetic data were genotyped using the Illumina HumanCore Exome and imputation carried out in Minimac 5-12-29 to the European component of 1000 genomes (Hughes and Kumari, 2019). Samples are checked to ensure genetic data is consistent with key information provided, such as gender and ethnicity. Quality control checks removed SNPs with a minor allele frequency of <1%, call rate threshold <98%, Hardy-Weinbery Equilibrium $p<10^{-4}$, or cluster separation score <0.4 (Hughes and Kumari, 2019).

Three genetic variants are used as instruments for circulating testosterone based on the Genome Wide Association Study (GWAS) of Ohlsson et al. (2011). These are rs12150660 and rs6258 in the SHGB gene on chromosome 17 and rs5934505 near FAM9B on the X chromosome. rs12150660 was imputed, whereas rs6258 and rs5934505 were genotyped (Hughes and Kumari, 2019).

3.3 Longitudinal data

In each wave of Understanding Society, survey respondents are asked about their current labour force status. This information is used to estimate the labour market transition between the nurse visit and the following survey wave . We start by trimming the nurse visit sample (when biomarkers are collected) to include only men who provide information on their social and economic circumstances, including the current labour force status.[11] We restrict the sample to men who state being either unemployed or, if employed, an employee. We drop self-employed individuals since this group of individuals is likely to differ from employees on unobservable characteristics (such as personality type) as well as their labour supply behaviour. Also, the sample size is insufficient to include them as a separate group.

In the next step, we merge this sample to the mainstage wave of Understanding Society. As noted above, the nurse visit took place shortly after either Wave 2 or Wave 3.[12] The interviews in the primary survey were conducted, on average, virtually one year apart. However, the time difference between the nurse visit and the follow-up interview at the primary survey is less than one year. We restrict our sample to individuals who are either employed or unemployed at the follow-up interview. Our final sample consists of 2,115 individuals, out of which 111 (5.25%) were unemployed during the nurse visit, and 2,004 were employed (94.75%).

[11] Possible answers are: (1) self employed, (2) paid employment(fulltime/parttime), (3) unemployed, (4) retired, (5) on maternity leave, (6) family care or home, (7) full-time student, (8) long-term sick or disabled, (9) government training scheme, (10) unpaid, family business, (11) on apprenticeship, (12) doing something else.

[12] We drop individuals who have a different labour market status at the wave prior the nurse visit. We introduce this restriction to avoid short-term labour market changes affecting the measured testosterone level.

4 Methodology

We aim to understand how the individual's testosterone level impacts labour market changes between the nurse visit and follow-up interview one year later in the primary *Understanding Society* survey. We distinguish between employed and unemployed men aged between 25 and 64. The reduced form model for unemployment can be written as follows:

$$y_i = \mathbf{1}(\alpha_1 y_{i(t=0)} + X'_{i(t=0)}\beta + u_i > 0) \tag{1}$$

where the subscripts $i = 1, \ldots, N$ are individuals and the dependent variable (y_i) equals 1 if i was unemployed at the first interview post nurse-visit. y_i is explained by the labour market status during the nurse visit, $y_{i(t=0)}$, and vector of explanatory variables $X_{i(t=0)}$, which were also collected during the nurse visit. As covariates, we include: age (linear and quadratic), highest qualification, self-rated health, region, urban identifier, household size, long-term disability, legal marital status, % body fat, smoking behaviour, as well as consumption of beta blockers or Central Nervous System (CNS) medication. u_i is an idiosyncratic shock. As the outcome variable is dichotomous, a normalisation of u_i is required. We take $\sigma_u^2 \sim N(0,1)$ and the outcome probability is:

$$P_{it}(y_{it} = 1) = \mathbf{\Phi}\left[\alpha_1 y_{i(t=0)} + X'_{i(t=0)}\beta)(2y_{it} - 1)\right] \tag{2}$$

Note that $\mathbf{\Phi}[\cdot]$ refers to the cumulative standard normal distribution.

As we outlined in section 2.2, it is possible that the effects might differ for those who are initially employed compared to those who are initially unemployed during the nurse visit. Therefore, we estimate separate regressions based on the labour force status during the nurse visit.

Testosterone levels vary over the course of the day, and unemployed men might be more likely to participate in their UKHLS interview during working hours than working men. To ensure comparability of testosterone, we adjust the circulating testosterone levels for age and time of the day when the blood sample was taken. We use the Health and biomarkers Survey to construct a sample of men with a positive level of testosterone in the age range 25 to 64 whose interview started between 8 am and 8 pm $(N = 3{,}597)$. We form four age groups, spanning the following ages: 25-34, 35-44, 45-54, and 55-64. Next, for each age group, we estimate the diurnal change of testosterone by regressing the absolute level of testosterone (nmol/l) and controlling for the time difference of the nurse visit (hour and minute) to 10 am.[13] We use the beta coefficients to correct the individual's testosterone level and standardize them to 10 am. Afterwards, we calculate the deviation by taking the difference between the estimated age-group specific and time-corrected sample mean and the individual's corrected testosterone level. In our first regression model, we include the age- and time-adjusted testosterone in nmol/l as a covariate (Model 1). In a further specification, we include the corrected testosterone level as a second-degree polynomial

[13] We checked for a non-linear relationship between time of the day and testosterone level but not indications were found.

(Model 2). In our last specification (Model 3), we form three groups based on the distribution of the deviation of individual testosterone levels from the age-group specific and time-corrected sample means within each age group: (i) low level of testosterone if the deviation belongs to the lowest quartile, (ii) medium level of testosterone if the deviation is in the 2nd to 3rd quartile, and (iii) high level of testosterone if the deviation belongs to the highest quartile. In a robustness check, we re-estimate our regression specifications adjusting the cut-off point defining low, medium, and high levels to ensure our results remain stable and are not driven by these definitions.

4.4 Mendelian Randomisation

Mendelian Randomisation (MR) uses genetic variation to shed light on the causal relationships between one or more modifiable risk factors and a particular outcome (Davies et al., 2018). One of the main strengths of this approach is that, under certain conditions, it can resolve the issue of unmeasured confounding by using genetic variation, which is fixed at conception, to help identify causal effects. In this study, we use MR to provide additional support for our main findings based on the probit specification outlined in the previous subsection.

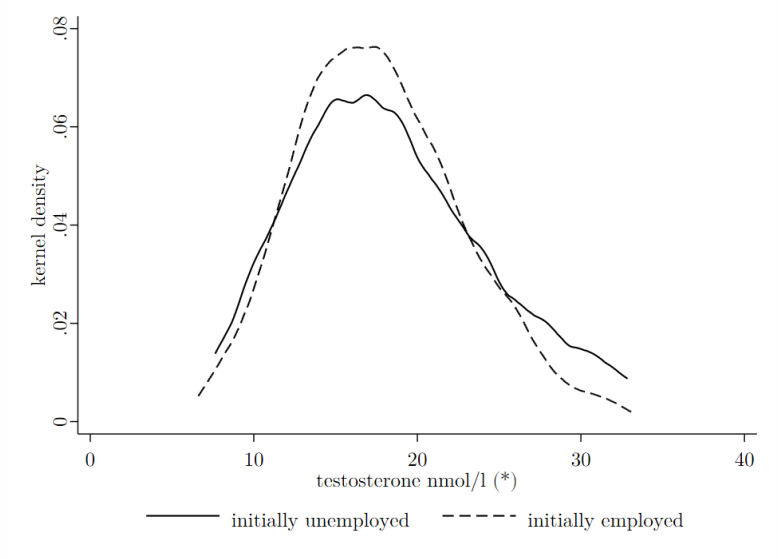
Genetic variants act as so-called instrumental variables and therefore must satisfy four conditions in order to be valid: (i) relevance, (ii) independence, (iii) exclusion, and (iv) monotonicity. In our case, this means that the instruments must be (i) associated with the testosterone, (ii) there must be no unmeasured confounders linking genetic variants and unemployment, (iii) the genetic markers only affect unemployment dynamics via their effect on testosterone, and (iv) the genetic markers should affect testosterone levels in the same direction for all observations. We consider the plausibility of these assumptions in the context of our study using various diagnostic checks (see inter-alia Davies et al., 2018).

Instead of using the three genetic markers (rs12150660 and rs6258 in the SHGB gene on chromosome 17 and rs5934505 near FAM9B on the X chromosome) separately, following Hughes and Kumari (Hughes and Kumari, 2019), we combine them into a single measure (polygenic score) using the beta values from Ohlsson et al. (2011). This is done to improve their statistical power and reduce the possibility of biased results due to weak instruments. We then use the individual-specific polygenic score to predict testosterone level using a standard IV model.

5 Descriptive statistics

The economic literature has shown that unemployment risk is influenced by factors such as qualifications, age, health, etc. In our study, we test the explanatory power of testosterone. When we split the sample into initially unemployed and employed (columns three and four of **Table 2**), we can see that these groups differ with respect to observable characteristics. For example, there is a significantly higher share of individuals without a higher qualification or whose health is not good or better among the initially unemployed.

Figure 2: Level of testosterone (nmol/l) by labour market status at the nurse visit



Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. $N = 2{,}115$ men with a positive level of testosterone in the age range 25 to 64 who had their interview started between 8 am and 8 pm and who were either employed (and an employee) or unemployed. (*) showing the level of testosterone (nmol/l) corrected by the time of the nurse visit.

We also find some differences in the distribution of corrected testosterone. The sample of initially unemployed has, on average, a higher level of testosterone, but the difference is not statistically significant. Further, we do not find significant differences when looking at the three testosterone groups described earlier. The kernel density plot shown in **Figure 2** indicates a slightly larger tail at higher levels of corrected testosterone.

Table 2: Descriptive statistics measured at nurse visit

	Full Sample	Initially unemployed	Initially employed	t-test (p-value)
Testosterone (nmol/l)	17.73	18.35	17.70	0.190
	(5.09)	(5.85)	(5.04)	
Testosterone (categorical, %)				
1st quartile	24.40	28.83	24.15	
2nd – 3rd quartile	50.35	40.54	50.90	
4th quartile	25.25	30.63	24.95	0.104
Age	44.78	45.05	44.71	0.176
	(10.12)	(10.06)	(10.13)	
Highest qualification (%)				
Degree	29.74	15.32	30.54	
Other higher degree	12.15	10.81	12.23	
A-level etc	22.98	18.02	23.25	

	Full Sample	Initially unemployed	Initially employed	t-test (p-value)
GCSE etc	21.75	28.83	21.36	
Other/No qualification	13.38	27.03	12.62	0.000
General Health (%)				
excellent	17.45	9.91	17.86	
very good	40.76	26.13	41.57	
goof=d	29.22	32.43	29.04	
fair/poor	12.58	31.53	11.53	0.000
Region of residence (%)				
England	84.78	96.40	84.13	
Wales	6.19	3.60	6.34	
Scotland	9.03	-	9.53	0.001
Rural area (%)	22.46	16.22	22.80	0.105
Number of people in household (%)				
1	12.62	28.83	11.73	
2	30.35	27.93	30.49	
3	20.80	14.41	21.16	
4+	36.22	28.83	36.63	0.000
Long-standing illness or disability (%)				
	27.00	36.94	26.45	0.015
Legal marital status (%)				
single	23.83	47.75	22.50	
married	63.92	31.53	65.72	
separated, divorced, widowed	12.25	20.72	11.78	0.000
% body fat				
	23.37 (8.41)	24.31 (9.60)	23.31 (8.34)	0.223
Smoking (%)				
	18.68	47.75	17.07	0.000
Beta blockers (%)				
	3.03	4.50	2.94	0.350
CNS medicine (%)				
	8.98	18.92	8.43	0.000
N	2,115	111	2,004	

Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. $N = 2{,}115$.

One way to assess intertemporal changes in the labour market position is to consider transition matrices. In **Table 3**, the probability of being (un)employed at t (the first interview after the nurse visit), conditional on the labour market position at $t-1$ (the nurse visit) is presented. The largest probabilities are on the main diagonal, which means that individuals either stay employed or unemployed and do not move between different labour market statuses. However, we see that the fraction moving from unemployment into employment is substantially larger than the one entering unemployment after stating being employed at the nurse visit.

Table 3: Transition matrix of labour market status

	employed$_t$	unemployed$_t$	Total$_{t-1}$
employed$_{t-1}$	97.21	2.79	94.75
	(1,948)	(56)	(2,004)
unemployed$_{t-1}$	39.64	60.36	5.25
	(44)	(67)	(111)
Total$_t$	94.18	5.82	
	(1,992)	(123)	

Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. $N = 2{,}115$. Numbers in ( ) refer to the sample size.

We differentiate the transition matrix further according to the testosterone groups to which an individual belongs (see **Table 4**). We find that for initially unemployed men, the conditional probability of staying unemployed is highest in the first quartile (75 per cent) – especially with respect to the 2nd – 3rd quartile (49 per cent). For initially employed men, we find that those in the top quartile have the highest conditional probability of entering unemployment (3.6 per cent). A general pattern in **Table 4** is that low testosterone is associated with higher persistence of unemployment, while high testosterone seems to be associated with a higher risk of entering unemployment.

Table 4: Unemployment risk differentiated according to testosterone level

Testosterone (categorical)	Initially unemployed	Initially employed
unemployed$_t$		
1st quartile	75.00	2.48
2nd – 3rd quartile	48.89	2.55
4th quartile	61.76	3.60

Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. $N = 2{,}115$.

6 Results

6.1 Baseline regression

Our baseline model controls for the labour market position and additional covariates collected during the nurse visit. Furthermore, we include the level of testosterone in three different alternative specifications. **Table 5** shows only the effect of testosterone and unemployment risk (complete output tables are available on request).

The first regression uses the full sample (see the first columns (1)-(3) of **Table 5**) and includes the age- and time-corrected level of testosterone in a linear trend (1), a quadratic trend (2), and as a categorical variable (3). In the first specification, we find that the unemployment risk increases with the level of testosterone. When moving to Model (2), we find a U-shape relationship, reaching the lowest value around a testosterone level of 18 nmol/l and then increasing again. The latter finding is mirrored by our last specification, where men with a testosterone level in the 2nd or 3rd quartile face a lower risk of becoming unemployed. However, the magnitude is always small in all three specifications, and estimates are not significantly different from zero.

In section 2, we outlined potential reasons why we might expect the effect of testosterone to differ between those who were unemployed and those who were employed during the nurse visit. Once we distinguish by the initial labour market status (columns (4)-(9) of **Table 5**), we see that the direction of the effect and the magnitude change substantially. For those who are initially unemployed, **Table 5** (column (4)-(6)) indicates that the risk of staying unemployed declines in the level of testosterone.[14] Although the significant quadratic term in column (5) indicates a non-linear effect of testosterone, column (6) suggests that the difference between the medium and high testosterone groups is rather modest.

In contrast to the sample of initially unemployed, we do not find significant effects in any of the specifications considered for the sample of initially employed men.

[14] In the case of Model (2), we see a decline in the unemployment risk until reaching a corrected testosterone level of 25 nmol/l.

Table 5: *Effect of testosterone on unemployment risk*

	Full Sample			**Labour market position during nurse visit unemployed**			**employed**		
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
testosterone nmol/l	-0.0038	-0.0332		-0.0693**	-0.4633**		0.0047	-0.0023	
	(0.0109)	(0.0585)		(0.0351)	(0.1977)		(0.0122)	(0.0689)	
(testosterone nmol/l)^2		0.0007			0.0096**			0.0001	
		(0.0015)			(0.0047)			(0.0018)	
testosterone									
1^{st} quartile					*reference category*				
2^{nd} – 3^{rd} quartile			-0.1602			-1.3653***			-0.0207
			(0.1345)			(0.4699)			(0.1545)
4^{th} quartile			-0.0268			-1.4097**			0.1257
			(0.1518)			(0.0575)			(0.1721)
Observations	2,115	2,115	2,115	111	111	111	2,004	2,004	2,004
Log Likelihood	-315.590	-315.462	-314.724	-51.355	-49.075	-48.211	-243.558	-243.553	-243.076

Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. $N = 2{,}115$. All models control for age (linear and quadratic), highest qualification, self-rated health, region, urban identifier, house-hold size, long-term disability, legal marital status, % body fat, smoking behaviour, beta blockers, Central Nervous System medicine. Model 1 includes a linear trend in circulating corrected testosterone, Model 2 models corrected testosterone with a quadratic polynomial, and Model 3 includes testosterone as a categorical variable.

We also calculate the average partial effects (APE) for Model (3) for the two subsamples. The partial effect is the difference (in percentage points) of staying or becoming unemployed if the person had a testosterone level in the second to the third quartile, resp. the top quartile, compared to the first quartile.

Table 6: *Average partial effects*

	Labour market position during the nurse visit	
	unemployed	**employed**
1^{st} quartile	*reference category*	
2^{nd} – 3^{rd} quartile	-0.2930***	-0.0012
	(0.0832)	(0.0090)
4^{th} quartile	-0.3042***	0.0083
	(0.1049)	(0.0113)
Observations	111	2,004

Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. ***,**,* refers to statistically significant at 1%, 5% and 10% level respectively

Compared to the lowest category, the unemployment risk for those who were unemployed during the nurse visit is reduced by 29.3 percentage points for the medium category and by 30.4 percentage points (both estimates significant at the 1% level) by the higher category. While these are very large effects, they are overall comparable to the differences in transition probabilities shown in Table 4. In the case of those men employed during the nurse visit, the magnitude of the APE is only positive for the top quartile, and the magnitude is small.

6.2 Robustness checks for the initially unemployed

In order to assess the sensitivity of our main results, we carry out a number of robustness checks.[15] As we only detected strong effects for the group of men who were unemployed during the nurse visit, we restrict discussion to this particular group. Our focus is to understand the link between testosterone and labour market changes among working-age men. First, we want to test whether our findings are driven by a few observations at the top and the bottom of the testosterone level distribution. For this reason, we drop the top and bottom 5 percent of the corrected testosterone values. The number of observations drops by 13.5%, indicating that men with extreme testosterone values are overrepresented among the unemployed. **Table 7** shows the respective marginal effects, and we still find sizeable and highly significant effects of higher testosterone levels reducing the risk of staying unemployed. We further find no indications for a non-linear relationship between testosterone level and unemployment risk (See column (5) of **Table A 1**).

[15] Additional robustness estimations which are not described in detail here include dropping covariates. However, none of the tests lead to qualitatively different findings.

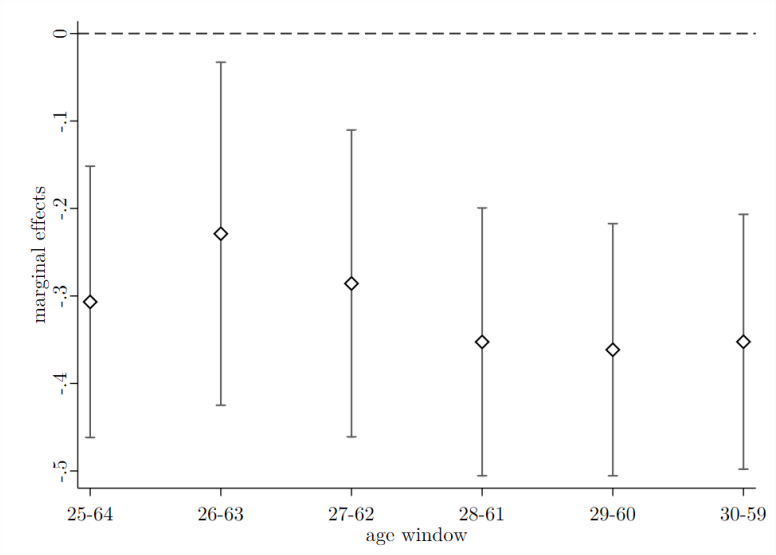
Table 7: *Average partial effects of truncated sample*

	unemployed during the nurse visit
1^{st} quartile	*reference category*
2^{nd} – 3^{rd} quartile	-0.2415**
	(0.0947)
4^{th} quartile	-0.3302***
	(0.1211)
Observations	96

Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. ***,**,* refers to statistically significant at 1%, 5% and 10% level respectively

Another concern is that our results are driven by the chosen age restriction (25-64). However, for those at the bottom and the tail of the sample, labour market decisions might be influenced by external factors. For example, individuals might consider delaying entry to the labour market due to attending university or reducing labour supply prior to entering retirement. We first narrow the age window by iteratively dropping the youngest and oldest age until the age range includes those between 30 and 59. The respective marginal effects for the categorical testosterone variable are shown in **Figure 3**. For simplicity, we have grouped the two highest testosterone groups together. Thus, the graph shows the marginal effect of belonging to the second or higher quartile compared to the bottom quartile. Across all age groups, we find a strongly significant reduction in unemployment risk for higher testosterone levels. Further, the variation in the magnitude only varies marginally across the different age windows.

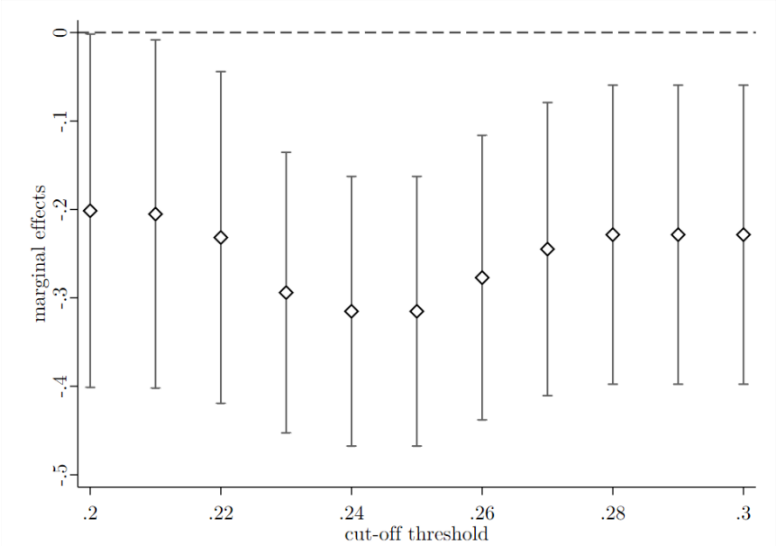
Figure 3: Robustness on different age-windows



Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. $N = 2{,}115$ men with a positive level of testosterone in the age range 25 to 64 who had their interview started between 8 am and 8 pm and who were either employed (and an employee) or unemployed. (*) showing the level of testosterone (nmol/l) corrected by the time of the nurse visit.

Next, we consider our categorisation of the variable defining the testosterone groups. We use the bottom and top quartile as cut-off points to determine the three categories in our main specification. We re-estimate the model and use as cut-off points for the bottom group 20 to 30 per cent, moving in one percentage points (see **Figure 4** for the marginal effects). We find that a higher testosterone level significantly reduces the risk of future unemployment, independent of the threshold used to distinguish between low and high levels.

Figure 4: Robustness on different cut-off thresholds



Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. $N = 2{,}115$ men with a positive level of testosterone in the age range 25 to 64 who had their interview started between 8 am and 8 pm and who were either employed (and an employee) or unemployed. (*) showing the level of testosterone (nmol/l) corrected by the time of the nurse visit.

6.3 Mendelian Randomisation

For the Mendelian Randomisation analysis, we only consider a specification with a linear trend in testosterone levels. Identifying a quadratic trend or separate groups would require additional instruments that predict variation between, e.g., medium and high levels of testosterone. The first-stage estimates shown in **Table A 2** show that the polygenic score is indeed highly predictive of testosterone levels. The top panel of **Table 8** shows estimates of the reduced form regression of the unemployment on the polygenic score as well as estimates from an IV-probit regression using the polygenic score as an instrument for testosterone. Based on the reduced form regression estimates, the lower part reports APEs for the coefficient of interest.

For the sample of unemployed men, we find that in the reduced form regression, a higher polygenic score is associated with a reduced probability of remaining unemployed. This suggests that men with a genetic predisposition towards higher testosterone levels were less likely to remain unemployed.

However, the causal effect of testosterone itself in the IV-probit model is imprecisely estimated. For employed men, we find that higher testosterone levels significantly reduce the risk of entering unemployment, both in the reduced form and the IV-probit model.

Table 8: *Mendelian Randomisation*

			Labour market position during nurse visit			
	Full sample		**unemployed**		**employed**	
Model	Reduced form	IV-Pro-bit	Reduced form	IV-Pro-bit	Reduced form	IV-Pro-bit
testosterone nmol/l		-0.12***		-0.03	-0.007**	-0.12***
		(0.03)		(0.93)	(0.003)	(0.05)
Polygenic score	-0.007***		-0.018*			
	(0.002)		(0.009)			
			Average Partial Effect			
Polygenic score	-0.0008***		-0.006**		-0.0005**	
	(0.0002)		(0.0027)		(0.0002)	
Observations	1,681	1,647	87	82	1,594	1,565
Log Likelihood	-380.35	-5215.10	-49.75	-298.60	-205.93	-4799.70

Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey.
***,**,* refers to statistically significant at 1%, 5% and 10% level respectively. Regressions control for first and second degree polynomials in age and the first 10 principal components.

Comparing these estimates to the results shown in Tables 5 and 6, we note that the Mendelian Randomisation analysis partly supports our conclusions. For the sample of unemployed men, we find a reduction in the probability of remaining unemployed both for our main specification in Table 5 and the Mendelian Randomisation analysis in Table 8. However, the point estimates in the Mendelian Randomisation analysis are considerably smaller, and the estimate in the IV-probit model is not statistically significant. Both the lack of precision and the smaller point estimate could be due to the limited explanatory power of the polygenic score for variation in testosterone levels. The first stage estimate for unemployed men in **Table A 2** is relatively small and not statistically significant. This means the polygenic score is only a weak instrument for testosterone in this subsample, likely due to the limited sample size. Moreover, the polygenic score only identifies variation in testosterone levels that is conceptually stable over the life course. It seems reasonable that the effects of such long-term differences on unemployment risk are smaller than the effects of both long-term differences and short-term fluctuations. Nevertheless, we interpret the significant reduced form effect as (partial) support for our conclusions.

For the sample of employed men, the finding of a reduction in the risk of unemployment in the Mendelian Randomisation analysis contradicts the small and insignificant estimate reported in our main specification. There are two possible explanations for this difference: First, we cannot rule out that these estimates reflect the conceptual difference between long-term differences in testosterone levels identified

in the Mendelian Randomisation model and short-term fluctuations in testosterone, which may dominate in our main specification. Second, the difference in the estimates might suggest that testosterone levels are indeed endogenous, and that the estimated (insignificant) effect in our main specification is upward-biased. Such upward bias could arise, e.g., from unobserved factors that are correlated with both elevated testosterone levels and a higher risk of unemployment. For example, previous studies indicate that divorce is associated with both elevated testosterone levels (Mazur and Michalek, 1998) and unemployment (Hansen, 2005). Occupational sorting could also explain such an upward bias either if men with high testosterone levels select into occupations with a high risk of unemployment or if occupational tasks in high-risk occupations lead to elevated testosterone levels (but not if testosterone has a causal effect on occupational choice).

Both of these explanations – conceptual differences between long-term and short-term variation in testosterone vs. endogeneity of testosterone – raise the question of why our estimates differ substantially for the sample of employed men but are more similar for the sample of unemployed men. It is difficult to imagine why the conceptual difference should affect employed men more than unemployed men. On the other hand, it is plausible that unobserved confounders and selection processes affecting the entry into unemployment differ from those affecting persistent unemployment. This suggests endogeneity as the more plausible explanation for the differences in our estimates.

7 Mechanisms

Our findings show testosterone affects men's transitions in and out of employment. Next, we examine whether these transitions can be explained by observed behaviour among individuals or by differences in cognitive skill-set. In section 2.2, we discussed potential channels through which testosterone may affect an individual's employment status. Although we cannot provide conclusive evidence for these mechanisms in this study due to data limitations, we consider several potential channels in a descriptive analysis to examine whether the associations in our dataset are consistent with the literature.

For example, in experimental studies numerical ability was related to testosterone (Brosnan et al., 2011), and data measuring such skills were collected at wave 3 in the UKHLS mainstage interview.[16] Survey respondent's practical numerical knowledge is assessed by testing whether they can understand percentages and fractions in typical real-life settings. Such ability measures have been shown to be highly related to wealth (McArdle et al., 2009; McFall, 2013). Individuals are presented with three initial problems, and if none are correctly answered, a further (simple) question is asked. On the other hand, if all questions are answered correctly, then an additional (more difficult) question is asked; if this was also

[16] This is approximately 7 months after the wave 2 nurse visit and 5 months before the wave 3 nurse visit, and hence relatively close to the date circulating testosterone is measured.

answered correctly, a further final question is asked.[17] Thus, an individual's final score is between zero (no correct answers) and five (all correct answers), and a clear ordering exists. Regression results (see **Table A 3** in the appendix) show that relative to individuals with a low testosterone level, the log odds of reporting a higher test score are 1.22 times higher (significant at the 5% level) among those with a medium level of testosterone.[18]

Alongside numerical ability, Understanding Society assesses an individual's fluid reasoning using logic puzzles (number series). Such measures have been found to be related to individual's financial knowledge (Delavande et al., 2008) and are negatively associated with age (Salthouse, 2010). [19] We, therefore, control for age in the regression analysis. Individuals in households were randomly allocated to a set of questions.[20] Within each 'set, individuals were asked six questions. An individual's final score ranged between zero (no correct answers) and six (all correct answers). Regression results (**Table A 4** in the appendix) show that relative to individuals with a low testosterone level, the log odds of reporting a higher test score are 1.20 (1.11) times higher among those with a high (medium) level of testosterone; however, not significant at conventional levels.

Occupational sorting could also lead to differences in unemployment risk for men with different testosterone levels. However, in our data, we do not observe an association between occupational class and testosterone levels, which earlier studies have found (Dabbs, 1992).

Research suggests that males with higher testosterone levels are more likely to express certain personality traits and behaviours in social and professional situations (Green et al. 2014, Dabbs et al. 2001). These same traits may help such individuals overcome adverse situations, such as unemployment. Understanding Society fielded a General Health Questionnaire at wave 3, which included attitudinal questions relating to whether individuals feel they have recently been able to face up to problems. In this case, individuals with medium and high testosterone levels were significantly more likely to report a response that suggested they had not lost the ability to face problems compared to individuals with low levels of testosterone. We also consider risk-taking, which has been associated with high testosterone levels (Apicella et al., 2008; Coates and Herbert, 2008). Respondents in Understanding Society were asked to rate their willingness to take general risks on a scale between 0 and 10, where higher values indicate a greater willingness to take risks. In a regression model controlling for age and real log earnings, we found a positive (though insignificant) association between being in the high testosterone group and reporting a higher score (OR=1.16).

[17] This test was adopted from the English Longitudinal Study of Ageing and some parts have also been included in the US Health and Retirement Study and Survey of Health Ageing and Retirement in Europe.
[18] Testosterone groups are defined as described in section 4.
[19] This test was developed for use in the US Health and Retirement Study.
[20] We only analyse the relationship between testosterone and responses to 'Set 1' as there was a CAPI coding error in 'Set 2'. See McFall (2013) for further details.

Individual's behaviour is also strongly correlated with their personality. For example, one might expect that individuals with higher testosterone levels are willing to search more intensely for a job ceteris paribus. In response to a question about job search in the last 4 weeks and asked to individuals who did not report being in paid work in the last week or having a job, those with a medium level of testosterone were significantly more likely to report using the internet to search for a job compared to unemployed individuals belonging to the low testosterone group. In addition, individuals were also asked about whether they used their network to explore employment opportunities. Based on purely descriptive evidence, the data suggest a higher proportion of the high testosterone group mentioned such a strategy. However, this result was not statistically significant. We also examine individuals' self-reported likelihood to lose their job in the next 12 months (very unlikely, unlikely, likely or very likely), and find a positive (though insignificant) association between those individuals who belong to the high testosterone group and the likelihood of job loss (OR=1.13, controlling for age and real log earnings).

In summary, the associations found in Understanding Society are in line with earlier studies, showing that testosterone is positively associated with numerical ability as well as personality traits such as risk-taking and self-confidence. Moreover, we also find some descriptive evidence for differences in job search behaviour. While we cannot conclusively prove that these potential mechanisms explain the observed relationship between testosterone levels and unemployment, we interpret our descriptive findings as suggestive evidence that such mechanisms are likely to play a role.

8 Conclusion

This paper examines the relationship between testosterone levels and unemployment dynamics among men in the UK. Our probit regression model controlling for previously identified confounders suggests that among unemployed individuals, those with medium and high testosterone levels are significantly more likely to leave unemployment compared to those with testosterone levels in the lowest decile. In contrast, for our sample of employed men, we do not find significant effects of testosterone on the risk of entering unemployment. We address endogeneity in testosterone levels in a Mendelian Randomisation analysis, using genetic variants predicting testosterone levels as instruments for serum testosterone. We find a negative effect of testosterone on unemployment risk, both among unemployed men (only significant in the reduced form regression) and among employed men (highly significant in both the reduced form and the IV-probit regression).

Descriptive evidence suggests that these effects might be driven by differences in cognitive and non-cognitive skills, occupational sorting, and differences in job search behaviour. Our findings have important implications for labour market policy. They demonstrate that latent biological processes can affect job search behaviour and labour market outcomes without necessarily relating to illness and disability. While we do not advocate determining the testosterone levels of unemployed men to improve their labour market outcomes, such differences can still be taken into account. For example, among

unemployed individuals participating in training programmes, profiling individual's personality traits, in order to determine the type and extent of assistance required (or whether sanctions should be applied), it is important to recognise that some differences in job search behaviour are driven by biological processes outside the control of the job seeker. Hence, certain types of men might require tailored assistance. For example, individuals with lower testosterone levels might benefit more from individual coaching rather than group sessions. Our results also suggest that individuals with high testosterone levels are at an advantage during the job search, although such hormonal differences do not necessarily translate into better productivity. In addition, awareness of the impact of personality and behavioural traits on performance during job interviews can potentially improve the quality of the job match.

While our results are robust to several specification changes, e.g., the included age range and the choice of cut-off points to define groups for testosterone levels, there are nevertheless some limitations. We control for several important factors that have been shown to affect both unemployment risks and testosterone levels in previous studies. In addition, we conduct a Mendelian Randomisation analysis to address potential endogeneity in testosterone levels by using individual's genetic predisposition towards testosterone levels as an instrument for observed levels. Although we interpret the estimates from the Mendelian Randomisation as causal effects (indicating that testosterone is endogenous in our probit specification), the results should be interpreted with caution. Our sample size is limited, particularly for unemployed men, and our models likely lack statistical power. Moreover, the polygenic score only predicts a limited amount of variation in testosterone levels, which further reduces the precision of the IV estimates. Taken together, these caveats likely explain why we find a significant effect in the reduced form regression of the polygenic score on unemployment risk for the sample of unemployed men, yet the IV estimate of the effect of testosterone is not significant.

Finally, genetic variants identify variation in testosterone levels that is conceptually stable across the life course. However, testosterone levels fluctuate considerably, e.g., with age and even during the day. It is not clear whether we should expect stable differences in testosterone levels to affect the unemployment risk of men or whether short- and medium-term fluctuations in testosterone levels drive these results. Repeated measures of testosterone would be useful to disentangle long-term differences in testosterone levels from short- and medium-term fluctuations. Unfortunately, our data do not allow us to test these differences since only one measurement of testosterone is available for each individual. Studying the mechanisms for which suggestive evidence was presented in this paper in more detail could also shed further light on this question. Moreover, we recommend that future research should examine the long-term cumulative effects of testosterone levels on labour market outcomes. Finally, it would be worthwhile to determine whether the findings extend to women.

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Appendix

Table A 1: *Effect of testosterone on unemployment risk (truncated sample)*

		Full Sample			**Labour market position during nurse visit** **unemployed**			**employed**	
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
testosterone nmol/l	0.0013	-0.0292		-0.1162**	-0.2490		0.0151	0.0132	
	(0.0142)	(0.1054)		(0.0510)	(0.3171)		(0.0158)	(0.1214)	
(testosterone nmol/l)^2		0.0008			0.0036			0.0000	
		(0.0029)			(0.0085)			(0.0033)	
testosterone									
1^{st} quartile				*reference category*					
2^{nd} – 3^{rd} quartile			-0.1221			-1.0837**			0.0377
			(0.1435)			(0.4928)			(0.1690)
4^{th} quartile			0.0068			-1.4312**			0.1944
			(0.1676)			(0.6315)			(0.1923)
Observations	1,918	1,918	1,918	96	96	96	1,822	1,822	1,822
Log Likelihood	-279.435	-279.392	-278.834	-43.842	-43.751	-43.220	-215.649	-215.648	-215.433

Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. $N = 2{,}115$. All models control for age (linear and quadratic), highest qualification, self-rated health, region, urban identifier, house-hold size, long-term disability, legal marital status, % body fat, smoking behaviour, beta blockers, Central Nervous System medicine. Model 1 includes a linear trend in circulating corrected testosterone, Model 2 models corrected testosterone with a quadratic polynomial, and Model 3 includes testosterone as a categorical variable.

Table A 2: *First stage estimates based on IV probit specification reported in* **Table 8**

	Full sample	Initially unemployed	Initially employed
Outcome: Testosterone (corrected)			
Variables			
Age	-0.303***	-0.404	-0.289***
	(0.0945)	(1.261)	(0.0969)
Age square	0.00274***	0.00400	0.00257**
	(0.00105)	(0.0144)	(0.00108)
PGS score	0.0421***	0.0126	0.0434***
	(0.00566)	(0.264)	(0.00582)
PCA1	13.96	11.25	18.49*
	(10.42)	(129.9)	(10.85)
PCA2	1.066	-4.767	0.475
	(10.06)	(107.0)	(10.53)
PCA3	2.417	101.2	-2.817
	(10.74)	(282.2)	(11.40)
PCA4	-13.61	55.67	-19.23
	(11.01)	(388.1)	(11.74)
PCA5	-5.605	-26.24	-0.725
	(10.94)	(97.55)	(11.61)
PCA6	4.134	-114.9	7.095
	(10.76)	(401.5)	(11.41)
PCA7	13.36	74.52	9.258
	(10.43)	(63.17)	(11.03)
PCA8	-23.57**	-65.39	-19.34
	(11.37)	(710.4)	(12.60)
PCA9	-2.080	-29.25	0.829
	(10.87)	(54.14)	(11.43)
PCA10	5.374	-22.95	5.103
	(10.07)	(71.95)	(10.72)
Rho	0.759***	0.281	0.718**
	(0.230)	(5.586)	(0.324)
Sigma	1.528***	1.569***	1.520***
	(0.0160)	(0.162)	(0.0165)
Constant	23.59***	26.88	23.24***
	(2.048)	(17.52)	(2.108)
Observations	1,647	82	1,565

Notes: Author's own calculations, using data from the Understanding Society subsample Health and biomarkers Survey. ***,**,* refers to statistically significant at 1%, 5% and 10% level respectively

Table A 3: *Numerical ability (proxied by number ability test) and testosterone level*

Specification	**Total score: numerical ability**
Testosterone group	
Low	Reference group
Medium	1.22***
	[0.09]
High	1.12
	[0.10]
Age	1.00***
	[0.003]
Observations	3,366
LogLikelihood	-4120.51

Notes: Author's own calculations using data from Understanding Society. Estimates based on sample of men aged 25-64 who responded at waves 2 or 3 and completed the survey module.
***,**,* refers to statistically significant at 1%, 5% and 10% level respectively. Coefficients refer to odds ratio (exp(β)).

Table A 4: *Fluid reasoning (proxied by logic puzzle test) and testosterone level*

Specification	**Total score: fluid reasoning**
Testosterone group	
Low	Reference group
Medium	1.11
	[0.11]
High	1.20
	[0.14]
Age	0.98***
	[0.004]
Observations	1,679
LogLikelihood	-3682.27

Notes: Author's own calculations using data from Understanding Society. Estimates based on sample of men aged 25-64 who responded at waves 2 or 3 and completed the survey module.
***,**,* refers to statistically significant at 1%, 5% and 10% level respectively. Coefficients refer to odds ratio (exp(β)).