The descent of a man's testosterone

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In work presented in PNAS, Gettler and colleagues (1) make an important contribution to our understanding of men's physiology. They find that, in a community-based sample from the Philippines, men with higher testosterone level are more likely to marry than men with lower testosterone; that men who marry and become fathers experience declines in testosterone; and that men who provide more paternal care have lower testosterone levels than fathers who provide less care. This is not the first study that has investigated the social dimensions to male testosterone levels. However, it represents perhaps the most rigorous study of its kind conducted on humans, and clearly demonstrates through a longitudinal design that fatherhood causes testosterone decreases in men. These findings merit attention from several angles.

Evolution of Human Fatherhood

Charles Darwin depicted a tree of life. At the terminal nodes of that tree, few mammals would be found in which males provided paternal care—only among approximately 5% of mammalian species (2). That figure is higher among primates than other groups of mammals (3). However, even among primates, the most invested nonhuman primate dads can be found in South America, where male titi monkeys, marmosets, and tamarins provide extended care of their offspring, helping carry them and occasionally even provision them (4). For humans, though, we take for granted that dads really care a lot of the time. We shouldn't, though (5). Few species of monkeys from Africa or Asia have paternal males. Our closest living relatives, chimpanzees and bonobos, with whom we last shared a common ancestor approximately 6 Mya, provide no meaningful degree of paternal care. Given the mating systems of chimpanzees and bonobos, a given male may not be aware of which offspring he has sired, much less devote time and attention to them. Various evolutionary models posit that human paternal care was derived recently (6, 7). Most models suggest that features of human paternal care—protecting, food provisioning, holding, playing, being available—arose within the past 2 million years in our genus *Homo*. A wider view thus highlights paternal care as a defining feature of our species.

Testosterone and Paternal Care

What are the physiological effects of paternal care on men? Much of the attention to this question has focused on testosterone. Interestingly, work on nonhuman animals helped set the theoretical and empirical stage for work on humans (8, 9). Wingfield and colleagues' "Challenge Hypothesis" (10), which synthesized many findings from birds, suggested that male testosterone levels would increase in association with male–male competition and courtship, but be lower during involvement in long-term partnerships and paternal care. Exemplary studies, like that of Ketterson et al. (11) in dark-eyed juncos, helped demonstrate the causal relationship between testosterone manipulations and male social behavior. Earlier primate work on testosterone and prolactin levels in common marmosets provided some further inspiration for conceptualizing whether and how human male testosterone levels might be impacted by forming long-term reproductive relationships and engaging in paternal care (12).

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The human studies finally took flight in the 1990s. A study of US Army veterans indicated that married men had lower testosterone levels than their single counterparts (13). A study among Air Force veterans indicated that men's testosterone levels increased around the time of divorce, offering a rare longitudinal insight into testosterone and men's relationships (14). Neither of these early studies, however, drew clear links with an evolutionary perspective (that human paternal care itself stood out, requiring study) or with nonhuman animal theoretical and empirical work such as that integrated under the Challenge Hypothesis. The first study that explicitly focused on fatherhood, rather than marriage or divorce, was conducted by Storey and colleagues (15). Apart from a few men who provided biological samples during a partner's late pregnancy and early postpartum period, that study showed that fathers had lower testosterone levels than control men in a cross-sectional design. A slew of studies conducted since then have found that partnered men and fathers typically have lower testosterone levels than their single counterparts (reviewed in ref. 16). As an example, married fathers had lower testosterone levels than married nonfathers and unmarried men in Beijing, China (17). However, all these studies relied on cross-sectional designs.

Strengths of Latest Findings on Men's Testosterone

Here is where the new study by Gettler and colleagues (1) shines: It is longitudinal. Accordingly, it can test whether baseline testosterone levels predict social outcomes and whether testosterone levels change in the wake of men becoming fathers. The answer, they show, is that baseline testosterone can predict some outcomes, such as men with higher testosterone marrying, but also that fatherhood causes decreases in testosterone among men. These are not unexpected findings. Wider principles of hormones and behavior have long indicated hormones can influence behavior (think of puberty or castrated pets, for example) just as behavior can influence hormones (try measuring stress hormones before and after a public speaking engagement) (8). The difference is that one can now reference data directly on these issues of men's testosterone and family relationships.

Other ways in which the study is important are that it contains a large sample (624 participants) and draws upon a community-based international sample. Many other studies focused on testosterone, marriage, and fatherhood have used considerably smaller sample sizes and have often drawn upon university-based samples. By building their study into an ongoing cohort study, the authors were able to benefit from that economy of research scale, also offering a model for further international work combining the best of social and biomedical science. Social psychologists, anthropologists, and others warn of the problems generalizing

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findings from Western, educated samples (18); the community-based sample in the Philippines helps avoid such pitfalls by incorporating a more representative sample based on educational and employment background.

Wider Implications

Ask a medical doctor what factors might diminish a man's testosterone. Chances are that age, circadian rhythm, sleep, obesity, and diabetes might quickly surface during the discussion. It is unlikely that a man's relationship status will arise. However, enough studies in the testosterone and male family relationships literature have been conducted, in concert with the wider nonhuman literature, to indicate that variables such as "partnership status," "fatherhood," and "invested paternal care" should enter that discussion too. No single variable will account for all the snapshot or longitudinal variation in men's testosterone levels, but the study by Gettler et al. (1) demonstrates the importance and effect size of these types of relationship variables. Indeed, another side of that coin is to ask what influences there may be of men taking exogenous testosterone on relationship parameters. Whether an older man using a testosterone gel or patch is more likely to form a new partnership or less likely to maintain a paternal relationship has not been studied.

One other social aspect of the study by Gettler et al. (1) is that it serves as a nice case study of the relevance of evolution to everyday human life. A markedly high percentage of Americans do not believe in evolution, and in particular wish to partial people outside of nature's operations (19). The wider evolutionary view, as noted earlier, highlights the comparatively rare and recently derived features of human fatherhood. The specifics of human paternal care exhibit considerable variation cross-culturally and longitudinally, an indication of how plastic our behavior can be, also downplaying any concerns of genetic or physiological determinism. However, if we had not evolved, why would male gonads act as if they had evolved under the influence of natural selection? More specifically, evolutionary theorists point out that the ultimate constraint on male reproductive success tends to be reproductive access to females (20); accordingly, we would expect males generally to be sensitive to male–male competition and courtship, if not also (in some species like our own) long-term partnerships and paternal care. Indeed, it is as if our gonads adhere to these very principles: the concentration of testosterone released from our testes tends to respond to these kinds of social cues, likely enhancing reproductive outcomes in the process. The descent of a man's testosterone may even be welcomed by some, perhaps his progeny.

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