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REGULATING GENETIC ADVANTAGE

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I. INTRODUCTION

Some things in life we have no control over; they are the result of luck. The genetic lottery has traditionally been the quintessential example of a realm where luck reigns. But our awareness of the inner workings of biological fortune and misfortune is accelerating. Scientists are uncovering new links between genes and attributes, illuminating how our genetics shape our lives.[1] But what if it were possible to change our genetics even in adulthood? Long a staple of science fiction plots, this alteration has recently become possible through a new wave of gene-editing techniques, particularly CRISPR.[2] Applications of the technology are developing rapidly.[3] The genetic modification of adults, particularly for reasons other than medical treatment, poses novel questions for contemporary society.[4] These questions stand apart from concerns about designer babies, even though the latter are attention-grabbing.[5] These adult enhancement applications have disruptive potential in both public and private domains such as: education, the job market, the marriage market, combat, disability rights, criminal justice, and the sports and entertainment industry.

The one domain with regulation already in place, as it foresees an early influx of adults who choose genetic modification, is sports. In 2003, the international oversight authority on the use of drugs in international sports events, the World Anti-Doping Agency ("WADA") preemptively banned athletes who have undergone genetic modification, branding such procedures as "gene doping."[6] WADA's motivation for the ban is the protection of natural talent, which it equates with ensuring a level playing field.[7] WADA's response to the perceived threat of adult

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1. *See, e.g.*, Peter M. Visscher et al., *10 Years of GWAS Discovery: Biology, Function, and Translation*, 101 AM. J. HUM. GENETICS 5, 5 (2017) (reviewing discoveries of complex traits relevant to disease); Suzanne Sniekers et al., *Genome-Wide Association Meta-Analysis of 78,308 Individuals Identifies New Loci and Genes Influencing Human Intelligence*, 49 NATURE GENETICS 1107, 1108 (2017) (reviewing genes influencing intelligence).

2. CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) and the protein Cas9 form a system that can be used for genetic modification. *See, e.g.*, Jennifer A. Doudna & Emmanuelle Charpentier, *The New Frontier of Genome Engineering with CRISPR-Cas9*, 346 SCI. 1, 1 (2014).

3. *See* discussion *infra* Section II.A.

4. Sarah Polcz & Anna Lewis, *CRISPR-Cas9 and the Non-Germline Non-Controversy*, 3 J. L. & BIOSCI. 413, 413 (2016).

5. *See id.* at 416 (describing commentaries from 2015 on human germline modification).

6. *See* World Anti-Doping Agency [WADA], *2004 Prohibited List*, at 6–7, World Anti-Doping Code (Mar. 2004) [hereinafter *WADA 2004 Prohibited List*], WADA_Prohibited_List_2004_EN.pdf [https://perma.cc/5VQS-GXVK].

7. *See Athletes*, WORLD ANTI-DOPING AGENCY, https://www.wada-ama.org/en/athletes [https://perma.cc/C9VT-TQQK] ("WADA strives to establish a level playing field, to allow them [athletes] to concentrate on the pursuit of athletic excellence through their natural talent — 'playing true'.").

genetic modification not only imposes prohibitions but also sets an agenda of moral education to shape public attitudes. WADA's rush to regulate genetic modification has ramifications from a broader societal perspective: with new technologies, decisions by early, influential movers can cause ripple effects in other domains.[8]

In contrast to WADA's top-down approach, the scientific community is actively encouraging urgent and widespread public engagement around the uses of these new technologies.[9] Scientists' motivations include promoting transparency, conferring legitimacy, and improving policy making,[10] all of which may mitigate the risk of a public backlash that could otherwise set back their agenda of advancing these technologies to alleviate human suffering. WADA, on the other hand, does not have the same motivations to ensure a robust public dialogue since the benefits of the technology fall outside of WADA's domain.

An empirical approach allows us to investigate what concerns weigh heavily with the public. Part of the challenge of public engagement is that the scientific community often structures its discussions around specific scientific techniques, which in important instances do not map to socially meaningful distinctions and values that an innovation may challenge.[11] Confronting this shortfall, in this paper we investigate public attitudes toward one socially meaningful application of genetic modification technology which we expect will be practiced early and often. Specifically, we consider when the genetic "have-nots" acquire advantageous genes that already exist within the human population but which are naturally possessed by only a select few.[12]

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8. *Cf.* Oona A. Hathaway, *Path Dependence in the Law: The Course and Pattern of Legal Change in a Common Law System*, 86 IOWA L. REV. 101 (2000) (discussing path dependence in the law).

9. *See* NAT'L ACADS. OF SCIS., ENG'G & MED., HUMAN GENOME EDITING: SCIENCE, ETHICS, AND GOVERNANCE 4 (2017) (arguing for public engagement to be incorporated into the policy-making process for human genome editing, particularly for applications "focused on goals other than disease treatment and prevention"); AM. COLL. OF MED. GENETICS & GENOMICS BD. OF DIRS., *Genome Editing in Clinical Genetics: Points to Consider — A Statement of the American College of Medical Genetics and Genomics*, 19 GENETICS IN MED. 723, 724 (2017) ("The ACMG Board of Directors strongly encourages broad public debate regarding the clinical application of genomic editing . . . .").

10. NAT'L ACADS. OF SCIS., ENG'G & MED., *supra* note 9, at 4 ("Meaningful engagement with decision makers and stakeholders promotes transparency, confers legitimacy, and improves policy making.").

11. *See* Dietram A. Schufele et al., *U.S. Attitudes on Human Genome Editing*, 357 SCI. 553, 553–54 (2017) (finding that whereas the major distinction discussed to date has been the heritability of changes, i.e., the germline/somatic distinction, individuals when questioned distinguish more between changes designed to be therapeutic versus enhancing).

12. This allows us to decouple such questions from applications we might expect to be more problematic, but which popular culture, for example, the X-Men, has brought into the lay concept of genetic modification. This would include modifications which some could feel erode what it means to be human and consequently overestimate public opposition to enhancement more narrowly construed.

Our study is the first to investigate public preferences for the regulation of genetic enhancement in sports. We find that whereas the public sees drug doping as rightfully prohibited, they do not see genetic modification for performance enhancement in the same way. With the unlevel playing field of inherited genetic advantage laid bare, people do not support protecting natural talent. It becomes clear this protection amounts instead to the defense of at-birth genetic advantages.

In Part II, we provide context on genetic modification, why sports were the first area to be regulated, the reasoning behind the ban, and the broader context of perceptions of fair outcomes. This sets the scene for our own experiments probing perceptions of fairness concerning gene doping, which we introduce in Part III. Part IV contains our Discussion and Part V our Conclusions.

II. BACKGROUND

A. Choosing Our Genetics

Throughout human history the only deliberate impact a parent could have on the genes of their offspring has been through their choice of mate. But opportunities to expand genetic choice are already arising. Parents using donated sperm or eggs are now able to select donors based directly on their genetics.[13] It has become a routine part of an in-vitro fertilization ("IVF") cycle to genetically screen embryos before they are transferred to the womb.[14] There are currently no legal barriers in the United States to choosing an embryo to implant based on genetic testing.[15] While today genetic screening is typically performed only for a handful of conditions, the technology is already mature enough to screen

13. *See, e.g.*, *Top Athletes*, SEATTLE SPERM BANK, https://www.seattlespermbank.com/athletes/ [https://web.archive.org/web/20170606161427/https://www.seattlespermbank.com/athletes/] [https://perma.cc/N2LJ-3UDU] (allowing Seattle Sperm Bank customers to select donors based on athleticism and lists evidence of athletic achievement such as "Division I" athlete and "professional soccer player."); *cf.* FAQs, GENEPEEKS, https://www.genepeeks.com/resources/faq/ [https://perma.cc/BX29-BXSZ] (using a "*Virtual Progeny*" approach to digitately combine genetics to predict risk of conceiving a child with a genetic disease).

14. *See* Robert Klitzman et al., *Preimplantation Genetic Diagnosis (PGD) on In-Vitro Fertilization (IVF) Websites: Presentations of Risks, Benefits and Other Information*, 92 FERTILITY & STERILITY 1276, 1279 (2009) (revealing that by 2008, 70% of IVF clinics were advertising Preimplantation Genetic Diagnosis).

15. Preimplantation Genetic Diagnosis has been used to select embryos based on sex, as well as by parents with disabilities who desire children with the same conditions, such as deafness or dwarfism, a practice which is not permitted in certain other nations. *See* Michelle J. Bayefsky, *Comparative Preimplantation Genetic Diagnosis Policy in Europe and the USA and Its Implications for Reproductive Tourism*, 3 REPROD. BIOMED. & SOC'Y ONLINE 41, 42 (2016).

for almost any genetic variant.[16] In *The End of Sex*, Hank Greely argues that in twenty to forty years, parents in developed countries will regularly use genetic testing in combination with embryo selection in order to maximize the chances their children will have the traits the parents desire.[17]

Beyond the ability to select an embryo comes the much more recently-developed ability to modify genetics. This can be done at the embryo stage or later. Modification of human embryos is an example of a *germline modification*, i.e. a change which enters the gene pool because it can be passed onto offspring. Adults can also be genetically modified; however, provided that such modifications do not encompass changes to their eggs or sperm, these modifications cannot be inherited. These changes are referred to as *somatic modifications*. The early promise of somatic genetic modification is the individualized treatment of genetically-caused diseases. Clinical research on such treatments started in the 1980s, and the first gene therapy was approved in China in 2003.[18] To date there have been nearly 2600 gene-therapy clinical trials.[19]

In the last five years, the genetic engineering field has been revolutionized by the new technology CRISPR. First demonstrated as a genome-editing technology in human cells in 2013,[20] this technology enables precise genetic changes to be made at nearly any location on a DNA molecule, by making molecular-level scissor-like snips. CRISPR is widely regarded as revolutionary in part because it is cheaper, more accurate, and simpler than earlier technologies.[21]

Clinical trials for somatic applications using CRISPR have already started.[22] On the germline side, a team of Chinese researchers announced

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16. *See* Brock A. Peters et al., *Detection and Phasing of Single Base De Novo Mutations in Biopsies from Human In Vitro Fertilized Embryos by Advanced Whole-Genome Sequencing*, 25 GENOME RES. 426, 426 (2015). In practice this would be very costly.

17. *See* HENRY T. GREELY, THE END OF SEX AND THE FUTURE OF HUMAN REPRODUCTION 191 (2016).

18. *See* Sue Pearson et al., *China Approves First Gene Therapy*, 22 NATURE BIOTECH. 3, 3 (2004).

19. J. GENE MED., *Gene Therapy Clinical Trials Worldwide*, ABEDIA (Nov. 2017), http://www.abedia.com/wiley/phases.php [https://perma.cc/HLD2-426Y].

20. *See* Le Cong et al., *Multiplex Genome Engineering Using CRISPR/Cas Systems*, 339 SCI. 819 (2013).

21. *See* ROYAL SOCIETY, *The CRISPR Revolution: Changing Life*, PROCEEDINGS OF THE ROYAL SOCIETY CONFERENCE ON BREAKTHROUGH SCI. AND TECHS. (Mar. 7, 2018), *available at* https://royalsociety.org/~/media/events/2018/03/crispr-revolution-tof/TOF-crispr-revolution-report.pdf?la=en-GB [https://perma.cc/VM45-8GNC].

22. The first clinical trial involving CRISPR started in China in October 2016. *See* David Cyranoski, *CRISPR Gene-Editing Tested in a Person*, 539 NATURE 476 (Nov. 15, 2016). The first trial in the US is due to start in 2018. *See* Sara Reardon, *First CRISPR Clinical Trial Gets Green Light from US Panel*, NATURE (June 22, 2016), http://www.nature.com/news/first-crispr-clinical-trial-gets-green-light-from-us-panel-1.20137 [https://perma.cc/GPR5-UQQ7]; *see also CRISPR Therapeutics and Vertex Announce FDA Has Lifted the Clinical Hold on the Investigational New Drug Application for CTX001 for the Treatment of Sickle Cell Disease*,

the first successful editing of a human embryo in 2015,[23] and in 2017 U.S. researchers repeated the feat.[24] These advances ignited a heated debate over the appropriate ethical and regulatory framework for such research.[25] The American College of Medical Genetics made an official statement in January 2017 advising that the "potential for rapid advance of this approach, and the pressure to apply it clinically, should not be underestimated."[26] On November 26, 2018, a Chinese researcher reported the birth of two children he had modified as embryos using CRISPR.[27] While to date, germline applications ("designer babies") have been at the center of this debate as they stand to introduce changes to the human gene pool,[28] there has been acknowledgement that policy attention should also be directed towards uses of genome modification technology to enhance the genetics of adults. For example, stakeholders — including the National Academies of Sciences and Medicine — have recently made urgent calls for public engagement to inform the policy-making process for human genome modification, particularly for enhancement applications.[29]

These calls for public engagement are made against a background of a near total absence of studies that solicit public input. A 2015 review of human enhancement public opinion surveys concluded that the area is

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CRISPR THERAPEUTICS (Oct. 10, 2018), http://ir.crisprtx.com/news-releases/news-release-details/crispr-therapeutics-and-vertex-announce-fda-has-lifted-clinical [https://perma.cc/N6RV-YNKN].

23. *See* Puping Liang et al., *CRISPR/Cas9-Mediated Gene Editing in Human Tripronuclear Zygotes*, 6 PROTEIN & CELL 363, 363 (2015). In 2016, Chinese researchers announced that they had edited the genome of a human embryo for a second time, making it resistant to HIV infection. *See* Xiangjin Kang et al., *Introducing Precise Genetic Modifications into Human 3PN Embryos by CRISPR/Cas-Mediated Genome Editing*, 33 J. ASSISTED REPROD. & GENETICS 581, 581 (2016).

24. *See* Hong Ma et al., *Correction of a Pathogenic Gene Mutation in Human Embryos*, 548 NATURE 413, 413 (2017).

25. Polcz & Lewis, *supra* note 4, at 413.

26. AM. COLL. OF MED. GENETICS & GENOMICS BD. OF DIRS., *supra* note 9, at 724.

27. Marilynn Marchione, *Chinese Researcher Claims First Gene-Edited Babies*, ASSOCIATED PRESS (Nov. 26, 2018), https://www.apnews.com/4997bb7aa36c45449b488e19ac83e86d [https://perma.cc/5Y86-E7LL] (At the time of going to press, this result had not been published in a peer reviewed journal or independently verified.).

28. *See, e.g.*, Antonio Regalado, *Engineering the Perfect Baby*, MIT TECH. REV. (Mar. 5, 2015), https://www.technologyreview.com/s/535661/engineering-the-perfect-baby/ [https://perma.cc/5B97-FP29]; Polcz & Lewis, *supra* note 4, at 413 (synthesizing discussion of germline and adult applications).

29. NAT'L ACADS. OF SCIS., ENG'G & MED., *supra* note 9, at 9. "RECOMMENDATION 6-2. Government bodies should encourage public discussion and policy debate regarding governance of somatic human genome editing for purposes other than treatment or prevention of disease or disability." *Id.* at 159. "RECOMMENDATION 7-3. Public participation should be incorporated into the policy-making process for human genome editing and should include ongoing monitoring of public attitudes, informational deficits, and emerging concerns about issues surrounding 'enhancement.'" *Id.* at 178.

understudied.[30] Since then, there have been two public opinion surveys of note. The first, commissioned by Pew Research Center, found that 42% of participants were supportive of gene editing to reduce babies' chances of disease if the babies would be far healthier than any known human, 52% were supportive if the babies would be much healthier than the average human today, and 54% were supportive if the babies were equally healthy as the average human today.[31] The National Academies of Sciences and Medicine, in their congressionally commissioned report on this topic, referenced this work: "the Pew study and many others suggest that policy in this area needs to be developed with full attention to public attitudes and understandings."[32] YouGov also conducted a study in early 2017, finding higher acceptance for genetic modification than previous surveys: acceptance or indifference towards somatic gene editing for therapy was approximately 83%, and for enhancement approximately 65%.[33]

B. Genetic Modification for Performance Enhancement in Sports

Eero Mäntyranta was a champion Finnish cross-country skier who competed in the 1960s. He was one of the greatest Olympians ever to compete in his sport: he won seven Olympic and five World Championship medals. He was found to have an abnormally high red blood cell count, which allowed his blood to carry more oxygen, in turn giving him a competitive edge. This abnormality led to accusations of cheating, and his victories were viewed with suspicion.[34] His name was only cleared two decades later when his family was selected for a genetic study that revealed that his elevated red blood cell count — 50% above average — was due to a rare genetic variant.[35] Two other members of his family who carry the same genetic variant also went on to be champion skiers.[36]

30. Anne M. Dijkstra & Mirjam Schuijff, *Public Opinions About Human Enhancement Can Enhance the Expert-Only Debate: A Review Study*, 25 PUB. UNDERSTANDING SCI. 588, 590 (2016).

31. Cary Funk et al., *U.S. Public Wary of Biomedical Technologies to 'Enhance' Human Abilities*, PEW RES. CTR. (July 26, 2016), http://www.pewinternet.org/2016/07/26/u-s-public-wary-of-biomedical-technologies-to-enhance-human-abilities/ [https://perma.cc/E5J3-2FFZ].

32. NAT'L ACADS. OF SCIS., ENG'G & MED., *supra* note 9, at 143.

33. Schufele at al., *supra* note 11, at 553.

34. *See* David Epstein, *Magic Blood and Carbon-Fiber Legs at the Brave New Olympics*, SCI. AM. (Aug. 5, 2016), https://www.scientificamerican.com/article/magic-blood-and-carbon-fiber-legs-at-the-brave-new-olympics/ [https://perma.cc/J3FV-CYQP].

35. *See* Albert de la Chapelle et al., *Truncated Erythropoietin Receptor Causes Dominantly Inherited Benign Human Erythrocytosis*, 90 PROC. NAT'L ACAD. SCI. 4495, 4498 (1993) (identifying the variant segregated in his extended family).

36. *See* Epstein, *supra* note 34.

Mäntyranta's case illustrates the important role genetics play in athletic ability. Athletes tend to have specific physiological attributes and are often from the same families.[37] Stephen Hsu argues that the "whole enterprise of competitive athletics has been, in effect, a search algorithm for genetic outliers . . . ."[38] Genetic variation in dozens of genes — over 120 individual genetic differences[39] — has been linked to sports performance.[40] Our understanding of the genetics underlying traits which predict athleticism is rapidly evolving and expanding as new genetic sequencing technologies make large-scale studies feasible.[41] Attempts to capitalize on these genetic links have begun in earnest,[42] with Uzbekistan announcing it will use the results of genetic testing to select individuals as young as ten for its Olympic training team.[43]

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37. *See* Van Jensen & Alex Miller, *Why Basketball Runs in the Family*, WALL ST. J. (June 13, 2016), http://www.wsj.com/articles/nba-basketball-runs-in-the-family-1464130236 (reporting that 49% of NBA players are related to an elite athlete).

38. Stephen Hsu, *We Are Nowhere Close to the Limits of Athletic Performance*, NAUTILUS (Aug. 11, 2016), http://nautil.us/issue/39/sport/we-are-nowhere-close-to-the-limits-of-athletic-performance [https://perma.cc/79EJ-AEVK].

39. Ildus I. Ahmetov & Olga N. Fedotovskaya, *Current Progress in Sports Genomics*, 70 ADVANCES IN CLINICAL CHEMISTRY 247, 250 (2015).

40. Our genetics influence a range of relevant traits including endurance ability, muscle performance, how the body regenerates after injury, how energy metabolism is regulated, how blood flow is controlled, and, how the body responds to stress. *See, e.g.*, Giuseppi Lippi et al., *Genetics and Sports*, 93 BRITISH MED. BULLETIN 27, 29, 32 (2010) (endurance ability, muscle performance); Table 1, *infra* Appendix I. For a review of how genetic linkages are ascertained, and some of the complexities involved, see João Paulo Limongi França Guilherme et al., *Genetics and Sport Performance: Current Challenges and Directions to the Future*, 28 REVISTA BRASILEIRA DE EDUCAÇÃO FÍSICA E ESPORTE 177, 178 (2014). The underlying genetics is not straightforward, with both common and rare variants contributing.

41. In January 2017 the leading genetic sequencing company, Illumina, announced that it would soon be possible to sequence an entire human genome for $100. Meghana Keshavan, *Illumina Says It Can Deliver a $100 Genome — Soon*, STAT (Jan. 9, 2017), https://www.statnews.com/2017/01/09/illumina-ushering-in-the-100-genome/ [https://perma.cc/79WV-5VKJ].

42. *See* Gabrielle T. Goodlin et al., *The Dawning Age of Genetic Testing for Sports Injuries*, 25 CLINICAL J. SPORTS MED. 1, 1–3 (2015) (reviewing the availability of tests intended to help reduce injury). For reviews of tests that help identify talented individuals, see Ahmetov & Fedotovskaya, *supra* note 39; Guilherme et al., *supra* note 40, at 180–83; Marios Kambouris et al., *Predictive Genomics DNA Profiling for Athletic Performance*, 6 RECENT PATENTS ON DNA & GENE SEQUENCES 229, 229 (2012). *But see* M. Alison Brooks & Beth A. Tarini, *Genetic Testing and Youth Sports*, 305 J. AM. MED. ASS'N 1033, 1033–34 (2011) (finding little evidence that genetic tests actually help prevent injury or select star athletes).

43. *See* Ron Synovitz & Zamira Eshanova, *Uzbekistan Is Using Genetic Testing to Find Future Olympians*, ATLANTIC (Feb. 6, 2014), http://www.theatlantic.com/international/archive/2014/02/uzbekistan-is-using-genetic-testing-to-find-future-olympians/283001 [https://perma.cc/8P2Q-MZAZ]. *Contra* Nick Webborn et al., *Direct-to-Consumer Genetic Testing for Predicting Sports Performance and Talent Identification: Consensus Statement*, 49 BRIT. J. SPORTS MED. 1486, 1486 (2015) (world experts asserting that "[t]he general consensus among sport and exercise genetics researchers is that genetic tests have no role to play in talent identification or the individualised prescription of training to maximise performance"). Such testing raises multiple ethical concerns, including eugenics and the treatment of minors. *See* Guilherme et al., *supra* note 40, at 189 (treatment of minors).

Many of the genetic targets for gene therapy align with potential targets for genetic modification for sports performance enhancement.[44] One reason why athletes may be early adopters of genetic modification is the overlap between genes of interest for diseases that will be early targets for gene therapy, and genes of interest for sports performance enhancement. Another reason is that athletes have shown themselves to be risk-takers when it comes to gaining a competitive edge.[45] WADA agrees, stating in its St. Petersburg Declaration that

> [T]he financial and personal rewards for enhanced performance in sport indicate that sport will be one of the areas in which gene-based enhancement is first likely to arise. The world of sport therefore serves as a very effective setting in which to examine broad societal issues of enhancement and the unclear boundary between treatment and enhancement.[46]

To summarize, there are good reasons to believe that genetic modification for performance enhancement in sports may not be too far off. This sense of imminence is the basis for a series of steps that have been taken by WADA, which we discuss below.

C. WADA's Ban on Genetic Modification for Performance Enhancement in Sports

WADA banned genetic modification for performance enhancement in its 2004 Prohibited List and clarified that this prohibition extended to technologies such as CRISPR in 2017.[47] WADA justified the ban on the basis that "the use of genetic transfer technology to dramatically enhance sport performance [is] contrary to the spirit of sport even if it is not

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44. *See* Table 1 *infra* Appendix I. For example, the gene therapy Neovasculgen, already approved in Russia, is a candidate for gene doping because of its role in generating new blood vessels. *See Neovasculgen*, HUMAN STEM CELL INST., http://eng.hsci.ru/products/neovasculgen [https://perma.cc/YG99-Y92X]; *see also* Table 1 *infra* Appendix I (gene VEGF).

45. *See* Polcz & Lewis, *supra* note 4, at 422.

46. *WADA St. Petersburg Declaration,* WORLD ANTI-DOPING AGENCY (June 11, 2008), https://www.wada-ama.org/sites/default/files/resources/files/WADA_StPetersburg_Declaration_2008.pdf [https://perma.cc/895H-MX5M].

47. *See WADA 2004 Prohibited List*, *supra* note 6, at 6 ("Gene or cell doping is defined as the non-therapeutic use of genes, genetic elements and/or cells that have the capacity to enhance athletic performance."); World Anti-Doping Agency [WADA], *Prohibited List January 2018*, at 6, World Anti-Doping Code (2018) [hereinafter *WADA 2018 Prohibited List*], https://www.wada-ama.org/sites/default/files/prohibited_list_2018_en.pdf [https://perma.cc/2UMC-MBDL] (adding "[t]he use of gene editing agents designed to alter genome sequences and/or the transcriptional or epigenetic regulation of gene expression").

harmful."[48] WADA has taken several practical steps towards enforcing this ban. It continues to invest "significant resources" in developing methods to detect gene doping.[49] It announced plans to retrospectively test athlete samples collected during the 2016 Rio Olympics for Erythropoietin ("EPO") gene doping, a form of blood doping that would give athletes a similar advantage to that with which Eero Mäntyranta was born.[50] Further, in February 2018, WADA announced that it was considering mandatory whole genome sequencing for athletes in order to enable detection of gene doping.[51] The addition of any enhancement method to WADA's list is tantamount to a sports-industry-wide ban,[52] and the

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48. WORLD ANTI-DOPING AGENCY, WORLD ANTI-DOPING CODE 4.3.2. Comment (2003) [hereinafter 2003 WADA CODE], https://www.wada-ama.org/sites/default/files/resources/files/wada_code_2003_en.pdf [https://perma.cc/H7WU-WDNJ] ("[T]he use of genetic transfer technology to dramatically enhance sport performance should be prohibited as contrary to the spirit of sport even if it is not harmful.").

49. *Gene Doping*, WORLD ANTI-DOPING AGENCY, https://www.wada-ama.org/en/gene-doping [https://perma.cc/53RR-5K4X] ("WADA is devoting significant resources and attention to ways that will enable the detection of gene doping"). For review of approaches to gene doping detection, see Ewa Brzeziańska et al., *Gene Doping in Sport — Perspectives and Risks*, 31 BIOLOGY SPORT 251 (2014).

50. *See* Sarah Everts, *Athletes at Rio Olympics Face Advanced Antidoping Technology,* CHEM. & ENG'G NEWS (Aug. 8, 2016), http://cen.acs.org/articles/94/i32/Athletes-Rio-Olympics-face-advanced.html [https://perma.cc/9PET-J7GB] (citing IOC's medical and scientific director Richard Budgett). It should be noted that WADA has been criticized for not allowing its tests to be statistically validated. *See, e.g.*, Donald A. Berry, *The Science of Doping*, 454 NATURE 692, 692–93 (2008) ("The processes used to charge athletes with cheating are often based on flawed statistics and flawed logic."). And on at least one occasion doping test results were overturned by the Court of Arbitration for Sports because WADA failed to establish the reliability of its decision limits. Veerpalu v. Int'l Ski Fed'n, CAS 2011/A/2566 (Ct. Arb. Sport 2013), http://www.tas-cas.org/fileadmin/user_upload/Bulletin_2013_2_complete.pdf [https://perma.cc/C25R-6A5L].

51. *See* Eric Niiler, *Olympics Could Require Athletes' Genetic Code to Test for Doping*, WIRED (Feb. 5, 2018, 7:00AM), https://www.wired.com/story/olympics-could-require-athletes-genetic-code-to-test-for-doping/ [https://perma.cc/UL8J-CW3L].

52. In 2014, inter-organizational harmonization led the NCAA, which covers nearly half a million student athletes, to amend its bylaws to prohibit gene doping. *See 2018-2019 NCAA Banned Drugs*, NAT'L COLLEGIATE ATHLETIC ASS'N, https://www.ncaa.org/sites/default/files/2016_17_%20Banned_%20Drugs_%20Educational_%20Document_20160531.pdf [https://perma.cc/U7RG-WWLW]; *see also* NAT'L COLLEGIATE ATHLETIC ASS'N, DIVISION I PROPOSAL — 2014-9, EXECUTIVE REGULATIONS — BANNED DRUGS — DRUGS AND PROCEDURES SUBJECT TO RESTRICTION — GENE DOPING, https://web3.ncaa.org/lsdbi/search/proposalView?id=3150 [https://perma.cc/9JGV-QBZB] ("This proposal allows the NCAA to honor suspensions for gene doping issued by the World Anti-Doping Agency (WADA)."). Consequently, as a result of the collegiate to professional athlete pipeline, many professional athletes will be subject to WADA's gene doping prohibition early in their careers. An additional signatory is the International Military Sports Council, which has over 130-member states and is the second largest multi-discipline sports organization after the IOC. This means that all military personnel competing as part of U.S. Armed Forces Sport are subject to the Code. ARMED FORCES SPORTS, ANTI-DOPING, http://armedforcessports.defense.gov/Portals/19/Documents/2015%20SOP/Appendix%20L%20Antidoping%20brief.pdf [https://perma.cc/6K69-U6MK].

penalties for violations significantly affect athletes' careers.[53]

WADA's self-proclaimed *raison d'être* is to defend the spirit of sport by establishing a level playing field.[54] Its prohibition decisions are designed to support this aim: the principal criterion it uses to justify banning an enhancement method is whether the method is "contrary to the spirit of sport."[55] The spirit of sport is defined in terms of the "dedicated perfection of each person's natural talents."[56] WADA is not required to justify its decisions, nor can these decisions be legally challenged on the grounds that WADA erred in applying its own criteria,[57] though this may conceivably change.[58] Nonetheless, WADA has made attempts to identify an organizing principle under which to unify its judgments of impermissibility. Two of these have been naturalness and normalcy,[59] both of which we argue neither work in theory nor have been applied systematically in practice.

What would count as "the dedicated perfection of each person's natural talents"?[60] Blood that has more EPO has higher oxygen-carrying potential and can increase performance.[61] But several things can increase EPO levels: training at high altitude, sleeping in a hyperbaric tent, ex-

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53. *See* Javier Maquirriain & Roberto Baglione, *Doping Offences in Male Professional Tennis: How Does Sanction Affect Players' Career?*, SPRINGERPLUS, 2016, at 1, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4942449/pdf/40064_2016_Article_2765.pdf [https://perma.cc/BP79-ZPSJ].

54. *See Athletes, supra* note 7.

55. 2003 WADA CODE, *supra* note 48, at 4.3.2. Comment.

56. WORLD ANTI-DOPING AGENCY, WORLD ANTI-DOPING CODE 14 (2015) [hereinafter 2015 WADA CODE], https://www.wada-ama.org/sites/default/files/resources/files/wada-2015-world-anti-doping-code.pdf [https://perma.cc/A2WT-UDE5].

57. Decisions from other adjudicative forums in which doping violations have been litigated offer little guidance on the spirit of sport or related concepts to which to turn. *See* Josephine R. Potuto & Matthew J. Mitten, *Comparing NCAA and Olympic Athlete Eligibility Dispute Resolution Systems in Light of Procedural Fairness and Substantive Justice*, 7 HARV. J. SPORTS & ENT. L. 1, 44 (2016). Moreover, the NCAA effectively precludes judicial review through its Restitution Rule. *See* Stephen F. Ross et al., *Judicial Review of NCAA Eligibility Decisions: Evaluation of the Restitution Rule and a Call for Arbitration*, 40 J.C. & U.L. 79, 100 (2014). Among the cases which stand as exceptions, none address the inclusion of substances on the banned list. Case law from Canada implicitly appeals to the intuition that doping rules are normatively justified in excluding substances that would interfere with sports as a test of biological potential, but with inadequate theoretical elaboration. *See, e.g.*, Johnson v. Athletics Canada, 114 O.A.C. 388 (Ont. C.A), ¶ 29 ("It is necessary to protect the right of the athlete, including Mr. Johnson, to fair competition, to know that the race involves only his own skill, his own strength, his own spirit and not his own pharmacologist.").

58. A case from the European Court of Justice, Case C-519/04, Meca-Medina v. Comm'n, 2006 E.C.R. I-6991, suggests courts could determine whether the prohibition of a method is excessive, beyond what can be justified to achieve the proper conduct of competitive sport.

59. *See Athletes, supra* note 7; Michael Le Page, *Anti-Doping Agency to Ban All Gene Editing in Sport From 2018*, NEW SCIENTIST (Oct. 9, 2017), https://www.newscientist.com/article/2149768-anti-doping-agency-to-ban-all-gene-editing-in-sport-from-2018/ [https://perma.cc/Y6BJ-MZ3U].

60. 2015 WADA CODE, *supra* note 56, at 14.

61. *See* discussion *supra* Section II.B.

tracting your own blood at an earlier date and injecting it at a later date, or injecting synthetic EPO.[62] The first two are not prohibited; the latter two are.[63] Surgical interventions, including performance enhancing interventions, are also not banned.[64] Moreover, the International Olympic Committee ("IOC") has taken issue with equating natural with fair, in their attempts to insist that some female athletes should only be allowed to compete in the Olympics in the female category if they artificially suppress their testosterone levels.[65]

More recently, in its 2017 update to the gene doping ban, WADA has relied on the concept of normalcy in justifying its position: genetic modification for therapeutic purposes will be allowed provided the modification does not produce an "enhancement beyond a return to normal."[66] However, what is normal can depend on factors such as age and ethnicity. For example, a genetic variant that is found in 9% of Swedish males but 67% of Korean males is associated with considerably lower natural testosterone levels.[67] Moreover, Olympic athletes are genetic outliers. Should sports authorities consider what is normal for an average human, or for an athlete, or for an internationally competitive athlete?[68]

The National Academies of Science and Medicine, in their congressional report on applications of genetic modification, critique reliance on concepts of natural and normal in this domain:

> Unless one assigns great importance to fate, it is difficult to tease out enhancements that allow individuals to fairly match the capacities of others from those that are

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62. *See* Steve Elliott, *Erythropoiesis-Stimulating Agents and Other Methods to Enhance Oxygen Transport*, 154 BRIT. J. PHARMACOLOGY 529, 533–34 (2008).

63. *See WADA 2018 Prohibited List*, *supra* note 47, at 6; *see also* DORIANE LAMBELET COLEMAN ET AL., DUKE CTR. FOR SPORTS L. & POL'Y, WHETHER ARTIFICIALLY INDUCED HYPOXIC CONDITIONS VIOLATE "THE SPIRIT OF SPORT" 1–2 (2006), https://www.law.duke.edu/features/pdf/hypoxiaresponse.pdf [https://perma.cc/L657-PVGS] (discussing the merits of a proposed WADA ban on artificially-induced hypoxic conditions).

64. *See WADA 2018 Prohibited List*, *supra* note 47.

65. *See* INT'L OLYMPIC COMM., IOC REGULATIONS ON FEMALE HYPERANDROGENISM (2012), https://stillmed.olympic.org/Documents/Commissions_PDFfiles/Medical_commission/2012-06-22-IOC-Regulations-on-Female-Hyperandrogenism-eng.pdf [https://perma.cc/BX6W-34W4].

66. Le Page, *supra* note 59.

67. Jenny Jakobsson et al., *Large Differences in Testosterone Excretion in Korean and Swedish Men Are Strongly Associated with a UDP-Glucuronosyl Transferase 2B17 Polymorphism*, 91 J. CLINICAL ENDOCRINOLOGY & METABOLISM 687, 689 (2006); *see also* Pilar Martín-Escudero et al., *Impact of UGT2B17 Gene Deletion on the Steroid Profile of an Athlete*, 3 PHYSIOLOGICAL REP. 1, 5 (2015) (discussing ethnic variations between Asians and Caucasians).

68. Between non-banned therapeutic applications and banned enhancements, there is also a gray area of preventative measures. *See* NAT'L ACADS. OF SCIS., ENG'G & MED., *supra* note 9, at 148. For example, genetic modification to lower cholesterol levels to below the average in the population may fall in the gray area. *See id.*

> "unnatural," "abnormal," or "excessive." Furthermore, any attempt to relate enhancement to what is "normal" or "average" risks categorizing efforts to combat widespread "normal" but undesirable aspects of life (e.g., age-related declining eyesight, hearing, and mobility) as a form of "enhancement," with all the pejorative connotations implied by the word.[69]

WADA's tacit exaltation of fate is also incongruent with its position that a level playing field is a precondition of fair play. Common moral intuitions as to the requirements for a level playing field are expanded upon in distributive justice work by legal theorists and reflected in research on behavioral economics. From the perspective of Ronald Dworkin and other thinkers within the *luck egalitarianism* tradition, a fair system is one where there is equality of opportunity.[70] Dworkin introduced the distinction between *endowments* and *ambitions*.[71] He argues that distributive inequalities are only just when they flow from one's choices (ambitions) rather than factors over which one has no control (endowments).[72] The idea that the role of luck should be minimized is not unique to luck egalitarianism. Rawlsian *relational egalitarianism* contends that a society in which the "natural lottery" plays a large role is immoral, and that when we can structure society to minimize the role of the natural lottery, we should.[73] Similar ideas drive lines of research in economics, where ongoing empirical work tracks individuals' decisions on redistributing winnings gained under various scenarios.[74] From these

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69. *Id.* at 149.

70. *See, e.g.*, RONALD DWORKIN, SOVEREIGN VIRTUE: THE THEORY AND PRACTICE OF EQUALITY (2000); Richard J. Arneson, *Equality and Equal Opportunity for Welfare*, 56 PHIL. STUD. 77 (1989); G.A. Cohen, *On the Currency of Egalitarian Justice*, 99 ETHICS 906 (1989).

71. *See* Ronald Dworkin, *What Is Equality? Part 2: Equality of Resources*, 10 PHIL. & PUB. AFF. 283, 311 (1981).

72. *See id.*

73. JOHN RAWLS, A THEORY OF JUSTICE 64 (revised ed. 1999); *see also* Carl Knight & Zofia Stemplowska, *Responsibility and Distributive Justice: An Introduction*, *in* RESPONSIBILITY AND DISTRIBUTIVE JUSTICE 1, 4–13 (Carl Knight & Zofia Stemplowska eds., 2011) (summarizing the debate on distributive justice).

74. *See* James Konow & Lara Schwettmann, *The Economics of Justice*, *in* HANDBOOK OF SOCIAL JUSTICE THEORY AND RESEARCH 83, 92-97 (Clara Sabbagh & Manfred Schmitt, eds., 2016). Contemporary results include those coming from Cappelen et al., who varied the amount of effort that went into determining outcome. They found that when outcomes were independent of effort, even distributions of winnings were preferred, but when outcomes depended on effort, distribution according to effort was preferred. *See* Alexander W. Cappelen et al., *Just Luck: An Experimental Study of Risk-Taking and Fairness*, 103 AM. ECON. REV. 1398, 1400 (2013). Other empirical work supports beliefs that individuals across cultures are more likely to hold others responsible if they had control over a situation. *See, e.g.*, Erik Schokkaert & Kurt Devooght, *Responsibility-Sensitive Fair Compensation in Different Cultures*, 21 SOC. CHOICE & WELFARE 207, 222 (2003). A recent study found that redistribution of

empirical studies an "accountability principle" has been postulated: an individual's fair allocation should be proportional to relevant variables they can influence, and not those variables they cannot influence.[75] The results suggest that individuals' fairness preferences often seek to minimize the role of luck in reward.[76]

While WADA has struggled to define a grounding principle to unify prohibition decisions, others have proposed less aspirational lines along which to distinguish which enhancements to prohibit, most notably by centering anti-doping policy around protecting the economic value of sports as an entertainment industry. Richard Posner has argued that the question of sports doping should be approached as a matter of audience preferences, and the theoretical project of defining the spirit of sport in grander terms should be rejected.[77] This view can be generalized to the proposition that institutions are legitimate to the degree to which they fulfill their main purpose as understood by their relevant constituency.

Operating under this model, audience preferences should be central to prohibition decisions, making the ascertainment of these preferences key to developing policy. To date, WADA's prohibition policies have not been based on data concerning public and consumer judgments of permissibility.[78] There have yet to be any public-attitude studies published on gene doping.[79] Even more surprisingly, we have been unable to

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gains was much higher if outcomes were the result of endowments ("brute luck") rather than when choice/ambition played a role. *See* Gustav Tinghog et al., *Are Individuals Luck Egalitarians? — An Experiment on the Influence of Brute and Option Luck on Social Preferences*, 8 FRONTIERS IN PSYCHOL. 1, 1 (2017). The study was designed to probe fairness preferences of 226 Swedish-based individuals involving real incentives. *See id.*

75. Konow & Schwettmann, *supra* note 74, at 92.

76. *See id. But see* Merve Akbaş et al., When Is Inequality Fair? An Experiment on the Effect of Procedural Justice and Agency (Jan. 2016) (unpublished manuscript), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2474368 [https://perma.cc/5HWF-VRY7].

77. *See* Richard Posner, *In Defense of Prometheus: Some Ethical, Economic, and Regulatory Issues of Sports Doping*, 57 DUKE L.J. 1725, 1738 (2008). For Posner, doping prohibitions may be justified and necessary to assure an economically efficient sports market. *See id.* Other commentators have arrived at the same position. *See* Antonio Rigozzi et al., *Doping and Fundamental Rights of Athletes*, 3 SWEET & MAXWELL INT'L SPORTS L. REV. 39, 43 (2003).

78. *See Prohibited List Q&A*, WORLD ANTI-DOPING AGENCY, https://www.wada-ama.org/en/questions-answers/prohibited-list-qa#item-391 [https://perma.cc/6RRR-QFY3] (listing three criteria for inclusion on prohibited list: enhances performance, poses health risk, violates spirit of sport); *see also* Aaron Gordon, *How Does WADA Decide What Drugs Are Banned?*, VICE SPORTS (Jul. 13, 2017), https://sports.vice.com/en_us/article/8xavbp/how-does-wada-decide-what-drugs-are-banned [https://perma.cc/C48E-K5P8] ("Basically, 'my way or the highway.'").

79. There are two studies surveying athletes. The first, an unpublished study of 115 U.S. student athletes from 2005 found that 60% thought gene doping was ethically equivalent to steroid use. *Results from Oregon College Athlete Gene Doping Survey*, GENEFORUM (2005), http://www.geneforum.org/node/489 [https://perma.cc/Q7YU-U564]. The second, a survey of eighty-one Dutch athletes and 52 Kinesiology professors found a high level of support for the proposition that gene doping formed a serious threat to fair play. Kris Dierickx et al., *The Ethics of Gene Doping: A Survey of Elite Athletes and Academic Professionals*, 3 J. CLINICAL

find any scholarly studies examining public attitudes toward doping (of any kind) in sports in the United States, though there have been several opinion polls conducted, showing strong disapproval for doping, with some evidence that attitudes may be becoming more lenient.[80]

This background contextualizes our empirical work. To summarize, our ability to modify genetics is imminent and there have been urgent calls for public engagement in shaping a regulatory response. Sports will be one of the first application areas for genetic enhancement, reflected in the fact that it is the only area to date with existing regulation specific to the issue. Genetic modification's use for enhancement has been banned, though the grounds for the ban are questionable. Prior work, both theoretical and empirical, highlights that minimizing the role of luck promotes a fair and just society. However, there have been no studies of public opinion on whether genetic modification for performance enhancement should indeed be banned. Our study fills in this gap. As we will go on to discuss below, our results can serve as a valuable lens for

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RES. & BIOETHICS, no. 2, 2012, at 2, https://www.omicsonline.org/the-ethics-of-gene-doping-a-survey-of-elite-athletes-and-academic-professionals-2155-9627.1000136.pdf [https://perma.cc/F9SL-4LH2].

80. In an opinion poll conducted in 2016, 61% of U.S. respondents stated that doping by some athletes decreased the attention they paid to the Olympics by "a lot" (41%) or "some" (20%). Press Release, BBC World Serv., Doping a Problem but Olympic Success Remains a Driver of National Pride: Global Poll (Jul. 26, 2016, 11:01 PM), http://globescan.com/images/images/pressreleases/bbc2016-olympics/BBC_Olympics_Pride_Poll_Press_Release_July_25.pdf [https://perma.cc/8WFQ-PM8S]. Polls of baseball fans have demonstrated a considerable (but declining) level of concern. *See* IPSOS PUBLIC AFFAIRS, *AP/AOL Poll: More than Half of Baseball Fans Say the Sport Hasn't Done Enough to Curb Use of Steroids*, IPSOS (Apr. 24, 2006), https://www.ipsos.com/sites/default/files/news_and_polls/2006-04/mr060424-1topline.pdf [https://perma.cc/2TF4-7TJZ] (showing 84% of respondents cared); Press Release, CBS News & N.Y. Times, Baseball And Steroids (Mar. 30, 2008), http://www.cbsnews.com/htdocs/pdf/March31-a-baseball.pdf [https://perma.cc/89X9-DHMM] (showing 82% of respondents who were at least somewhat interested in baseball cared); *Washington Post Poll*, WASH. POST (Jan 6. 2016), http://www.washingtonpost.com/wp-srv/politics/polls/postpoll_20130106.html [https://perma.cc/8ZP8-Q8K6] (showing 53% of respondents cared). There have been scholarly studies performed outside the United States, showing high concerns regarding doping. *See* Harry A. Solberg et al., *Doping in Elite Sport — Do the Fans Care? Public Opinion on the Consequences of Doping Scandals*, 11 INT'L J. SPORTS MKT'ING & SPONSORSHIP 185, 185 (2010) (showing no tolerance for doping in a survey of Norwegian sports fans); Stephen Moston et al., *Perceived Incidence of Drug Use in Australian Sport: A Survey of Public Opinion*, 15 SPORT IN SOC'Y 64, 64 (2012) (finding low support for doping amongst the Australian public); Hanspeter Stamm et al., *Attitudes towards doping — A Comparison of Elite Athletes, Performance Oriented Leisure Athletes and the General Population*, 11 EUR. J. SPORT & SOC'Y 171, 171 (2014) (showing lack of support for doping among Swiss respondents); Hanspeter Stamm et al., *The Public Perception of Doping in Sport in Switzerland, 1995–2004*, 26 J. SPORTS SCI. 235 (2008) (recording similar findings for an earlier period). A Belgian study of students' opinions of doping found that this demographic's opinion may be shifting from zero-tolerance to a more lenient approach. *See* Hans Vangrunderbeek & Jan Tolleneer, *Student Attitudes Towards Doping in Sport: Shifting from Repression to Tolerance?*, 46 INT'L REV. SOCIOL. SPORT 346, 346 (2010).

exploring the regulation of genetic modification in other areas besides sports.

III. Experimental Studies

In order to assess public attitudes towards "gene doping" we designed a study based on a scenario inspired by the case of Eero Mäntyranta.[81] To better understand the results of that first study, we designed a second study that allowed us to investigate the role of several factors in shaping public opinion.

A. Methodology of Study One

Our methodology is based around seeking reactions to the following scenario:

> BASE CASE SCENARIO: Scientists have discovered Gene Z relates to success in long distance competitive running. Gene Z enables more oxygen to be carried in the blood. Gene Z is not enough on its own; hard work, training, and diet are important contributing factors to winning.
>
> It is well known that scientists can now give Gene Z to people who are not born with it, at low cost. Some people will experience side effects, including higher likelihood of injury.
>
> Many race winners in the past 50 years have had Gene Z. A person without Gene Z would be less likely to win, even with hard work, training, and the right diet.

Our choice of enhancement was designed to closely model a real example of genetic variation naturally occurring in other humans.

We asked for reactions to two statements.[82] The first statement below probed whether subjects cared about the source of a given genetic advantage — the natural lottery of birth or an elective procedure. Because this scenario makes the unlevel playing field of natural talent sali-

81. *See* discussion *supra* Section II.B.

82. We asked participants to react to statements concerning the scenarios on a seven-point Likert scale (Strongly Disagree, Disagree, Somewhat Disagree, Neither Agree nor Disagree, Somewhat Agree, Agree, Strongly Agree).

ent, we hypothesized that subjects might not object to this type of procedure:

> ORIGIN OF ADVANTAGE NOT IMPORTANT: People who have chosen to acquire Gene Z should be permitted to race with people who were born with Gene Z.

The second statement aimed to directly capture reactions to gene doping, by asking whether individuals who choose to acquire this performance advantage should still be able to race alongside those who have chosen not to get it and therefore lack this performance advantage:

> ALLOW MODIFIED ATHLETES: People who have chosen to acquire Gene Z should be permitted to race with people who have chosen not to acquire Gene Z.

Subjects were asked to explain their responses by stating their support for a series of reasons.[83] Following their responses to the scenario, we asked a randomly selected half of the subjects for their reactions to the statement *Athletes should be allowed to dope* and the other half for their reactions to *Athletes should be allowed to take performance enhancing drugs*.[84]

Our *Base Case* scenario was answered by 400 U.S.-based individuals with representation designed to reflect census data across age (18-55), gender, and education level.[85] The study was run on Prolific, a crowdsourced online survey platform.[86] To assess the precision of our

83. We chose these reasons based on pilot data, and also provided an open-text option.

84. Finally, we asked whether they watched more than one hour of sports per week and whether they considered themselves religious.

85. We performed strata-based sampling using ten strata. The size of each stratum was determined based on U.S. 2010 Census data. We used the following strata, separately for men and women: 18- to 23-year-olds, 24- to 34-year-olds with college level education, 24- to 34-year-olds without college level education, 35- to 55-year-olds with college level education, 35- to 55-year-olds without college level education.

86. Prolific is an Oxford University Innovation company. PROLIFIC, https://www.prolific.ac [https://perma.cc/YU75-PAU7]. Participants are prescreened according to researcher specified criteria. The use of samples from such platforms has been shown to give comparable results to samples that are both randomly selected and designed to be representative of the U.S. population, particularly when age is taken into account, as it is in this study. *See* Jill D. Weinberg, et al., *Comparing Data Characteristics and Results of an Online Factorial Survey between a Population-Based and a Crowdsource-Recruited Sample*, 1 SOC. SCI. 292, 301 (2014). The authors obtained "substantively the same results" from the two platforms, particularly when accounting for participant age. *Id.*, at 307. Use of this platform gave us access to several dozen demographic data points. Participants were paid through this platform at a rate of $0.50.

estimates we used the bootstrap procedure.[87] Our data is publicly available.[88]

B. Results of Study One

1. Reactions to the Base Case Scenario

First, respondents agreed that the origin of the genetic advantage, natural birth versus artificial procedure, did not matter. Seventy-nine percent (79%) of respondents agreed or were indifferent to our *Origin of Advantage Not Important* statement. Of those who agreed, the reason with the most support was *You either have a gene or you don't, doesn't matter how you got it* (79%). There was also broad support for the two other statements presented, *Sports would be a fairer test if the biological playing field were more level* (67%), and *It would be hard to test whether someone was born with a gene or had it added later, so it would be pointless to try and prevent this happening* (68%). Of the minority who disagreed (21%), 44% (9% overall) endorsed the view that *Humans shouldn't interfere with genetics under any circumstances*.

For the *Allow Modified Athletes* statement, 54% agreed or were indifferent. The 46% minority who disagreed were asked to react to the following two statements: *People who have acquired Gene Z should not be permitted to race at all* (39% agreed, which is 18% overall) and

87. The bootstrap is a resampling approach, *see* James G. MacKinnon, *Bootstrap Hypothesis Testing*, *in* HANDBOOK OF COMPUTATIONAL ECONOMETRICS 183, 193 (David A. Belsley & Erricos John Kontoghiorghes eds., 2009), and is as recommended by the American Association of Public Opinion Research, *see AAPOR Guidance on Reporting Precision for Nonprobability Samples*, AM. ASS'N PUB. OPINION RES. (Apr. 2016), http://www.aapor.org/getattachment/Education-Resources/For-Researchers/AAPOR_Guidance_Nonprob_Precision_042216.pdf [https://perma.cc/4HH6-6JJ8]. We generated 100,000 independent "resamples" by randomly selecting 400 respondents with replacement from the original survey data set. Resamples were formed using the same 10 strata as our survey, such that we matched the same number of respondents from each stratum in each subsample. For our 100,000 resamples, we computed the statistic of interest (in this case the proportion of respondents who agreed or were indifferent to the question) and used the variability in these estimates as the basis of the confidence intervals reported. The confidence interval assumes that our estimates are approximately unbiased. Hypothesis testing was also performed using bootstrapping. For two cases we wished to compare (e.g. women's responses versus men's, or answers to one question versus answers to a variant question), the null hypothesis is that the responses come from the same distribution. Let the size of the first sample be N and the second M. We created 100,000 samples of the combination of the two cases and calculated the difference between the proportion of agreed and indifferent of the first N of each subsample and the proportion of agreed and indifferent in the final M of each subsample. We then compared the observed difference in proportion of agreed and indifferent to the list of 100,000 bootstrapped differences, and report as the p-value the fraction of times the bootstrapped difference had a greater magnitude than the observed difference.

88. Sarah Polcz, *Regulating Genetic Advantage*, OPEN SCI. FRAMEWORK https://osf.io/c96v7/ [https://perma.cc/6QRQ-ZHQM].

There should be a separate category for those who do not have Gene Z (74% agreed, 34% overall).[89]

2. Comparison to Attitudes Towards Doping

In reaction to the statement *Athletes should be allowed to dope*, 17% of our participants agreed or were indifferent. For the statement *Athletes should be allowed to take performance enhancing drugs,* 23% agreed or were indifferent. These numbers are very different from the 54% for our *Allow Modified Athletes* statement.

In order to understand why acquired genetic advantage is viewed more positively than advantages acquired from substances, and in order to test the robustness of our results under different conditions, we designed a second study.

C. Methodology for Study Two

We had two hypotheses as to what might account for this difference. First, that allowing genetic modification would garner more support than allowing drug doping because respondents believe it is not fair to protect the genetics one happens to be born with. And second, that branding something as a "drug" would prime people with negative associations. We made a total of six different modifications to our *Base Case* scenario in order to test these hypotheses and to test for robustness based on equality of access and the type of genetic modification. The six scenarios were *No Genetic Enhancements*; *Biomolecule, Natural Differences*; *Biomolecule, No Natural Differences*; *Drug, No Natural Differences*; *High Cost*; and *Psychological Enhancement*.

To test the first hypothesis, we designed three scenarios. The first was a *No Genetic Enhancements* scenario (i.e., one that represents the world today), identical to the *Base Case* except without mentioning the possibility of changing whether or not someone had Gene Z. We asked for reactions to the following two statements:

> ALLOW NATURALLY GENETICALLY ADVANTAGED ATHLETES: People who were born

89. In our sample size of 400, we found more support for both statements (*Origin of Advantage Not Important* and *Allow Modified Athletes*) among younger people. This is not surprising given that younger people tend to view biotechnology more favorably. We found no statistically significant difference between men and women, between Republicans and Democrats, or between those who self-reported as religious and those who did not. We did find that those who reported watching an hour or more sports per week were less supportive than those who did not for the *Origin of Advantage Not Important* statement (74% compared to 84%, p=0.006), though not for the *Allow Modified Athletes* statement.

> with Gene Z should be permitted to race with people who were not born with Gene Z.
>
> HAVE GENETIC CATEGORIES: People who were born without Gene Z should have a race category in which people who were born with Gene Z cannot compete.[90]

We designed two further scenarios to probe the effect of making clear that some athletes have an innate biological advantage. The second scenario, *Biomolecule, Natural Differences*, referred to *Biomolecule V*, and mentioned that *Different individuals' bodies naturally produce differing amounts of Biomolecule V.* The third scenario, *Biomolecule, No Natural Differences*, referred to *Biomolecule V* but made no mention of naturally occurring differences.[91]

Use of the term biomolecule in these two scenarios also allowed us to probe the second hypothesis, around the role of language. We designed a *Drug, No Natural Differences* scenario by replacing the word *Biomolecule* with the word *Drug* in the *Biomolecule, No Natural Differences* scenario.

Alongside testing these two hypotheses for explaining the higher level of support for performance-enhancing genetic modification versus drug doping, we were interested in the robustness of our result to two factors: (1) concerns about equality of access and (2) the type of genetic modification. To control for opposition based on concerns about equal access to genetic modification, we designed a *High Cost* scenario to see how changing the cost described in our scenario would affect respondent judgments. Where the base case scenario mentioned *low cost*, this scenario mentioned a *cost of $100,000*. To assess whether our results were robust to the type of enhancement, we designed a *Psychological Enhancement* scenario affecting psychological properties instead of physical ones: *Gene Z helps athletes feel a sense of reward after training and therefore helps them stick to a more intense training regime.*[92]

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90. This is reminiscent of real-life scenarios such as the Paralympics' using athlete biology to define separate categories or the Olympics using different categories for men and women. For further discussion, see *infra* note 110.

91. A biomolecule is a molecule that is present in living organisms.

92. We were also interested in public judgments when the individual undergoing the modification was a minor, because of the existence of a developmental window for modifications to take effect. For example, genetic variation linked to being taller would not produce extra height if introduced after someone had finished growing. One might have anticipated low support for the genetic modification of minors, owing to issues of informed consent, but this is not what we observed. Our results were in line with the more general case. We designed a scenario with three variants. The main scenario involving minors read:

To avoid participants' answers for any one study being unduly influenced by previous questions, we divided these six scenarios across three groups of 200 people (n = 600 in total).[93]

D. Results of Study Two

1. Challenging the Idea That the Genetics One is Born with Should Confer Protected Privilege

For our *No Genetic Enhancements* scenario, 14% of individuals disagreed with the *Allow Naturally Genetically Advantaged Athletes* statement. These respondents thought that some natural advantages should preclude athletes from competition. In response to the *Have Genetic Categories* statement, 43% agreed or were indifferent to introducing separate categories for those born with the named genetic advantage.

In response to a modified *Allow Modified Athletes* statement, 63% agreed or were indifferent in the *Biomolecule, Natural Differences* scenario, and 56% in the *Biomolecule, No Natural Differences* scenario. Our finding of lesser support for the second scenario ($p = 0.05$), supports the hypothesis that making salient the natural lottery may play a role in

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Jamie is 11 years old and wants to be a long-distance runner. Jamie was not born with Gene Z. Those who have Gene Z before they go through puberty will develop more efficient muscles and go on to have an advantage in long-distance running over those who did not have Gene Z during puberty. (If Gene Z is introduced after puberty it gives no advantage). Both Jamie and Jamie's parents would like for Jamie to be given Gene Z before puberty.

It is well known that scientists can now give Gene Z to people who are not born with it (including minors), at low cost. Some people will experience side effects, including higher likelihood of injury.

The three versions were

(1) *Development Window*: as above

(2) *No Development Window*: as above, but without any mention that the change needs to happen before puberty

(3) *Scholarship*: as (2), but with the following addition: *Many students who have won athletic scholarships to college in the past 50 years have had Gene Z. A student long distance runner without Gene Z would be less likely to win an athletic scholarship to college, even with hard work, training, and the right diet*.

We asked for the degree of support for the following statement: *Jamie should be permitted to acquire Gene Z.* Each of the three groups of participants in our second study received one of these scenarios. We found that 75% of our respondents agreed or were indifferent to the statement Jamie should be permitted to acquire Gene Z. Fifty-three percent (53%) of those who disagreed (13% overall) see issues with genetic modification of minors. We found no statistically significant difference in level of support to the other two variants of the scenario.

93. The quota was the same as for the *Base Case*, except the older age bracket extended to age forty instead of fifty-five. When we compared our *Base Case* scenario to the other scenarios, we subsampled the *Base Case* respondents to match the same age range. Participants were paid at a rate of $0.80.

increasing support for performance enhancement via genetic modification versus drug doping.

2. Effect of Language in Attitudes to Performance Enhancement in Sports

In the two scenarios which differed from each other only in use of the term *Biomolecule* versus *Drug* (*Biomolecule, No Natural Differences* and *Drug, No Natural Differences*), 56% versus 29% agreed or were indifferent to the *Allow Modified Athletes* statement, respectively. This difference is statistically significant ($p < 10^{-5}$).

3. Robustness of Our Results to Concerns of Equality of Access and to Modification Type

We found no statistically significant difference in the level of support for the *High Cost* scenario compared to our *Base Case* (low cost) scenario.

We found our results remained consistent when testing a different sort of genetic modification using the *Psychological Enhancement* scenario. Indeed, we found more support for this modification for both statements.[94] Why this difference? Perhaps because the psychological change is less directly related to what the competition (long distance running) is testing.[95]

IV. DISCUSSION

We designed a series of experiments to probe public judgments and isolate the impact of several variables of interest. Experimental participants were 1000 U.S.-based individuals, with proportional representation based on U.S. census data across age (18-55), gender, and education

94. Eighty-six percent (86%) agreed or were indifferent to the *Origin of Advantage Not Important* statement, and 66% to the *Allow Modified Athletes* statement for the *Psychological Enhancement* scenario. Indeed, we found more support for this modification for both statements ($p = 0.04$, $p = 0.01$).

95. This result — more support for psychological rather than physical modification — is consistent with the findings of the recently published survey of public attitudes to genetic modification more generally. *See* Dietram A. Scheufele et al., *Supplemental Materials for U.S. Attitudes on Human Genome Editing,* 357 SCI. (SUPP.) 4 (2017), http://science.sciencemag.org/content/sci/suppl/2017/08/09/357.6351.553.DC1/aan3708_Scheufele_SM.pdf [https://perma.cc/364Y-QQKF] (finding more support for enhancement of "a person's mental abilities, such as memory" than for enhancement of "a person's physical features, such as improving eyesight to beyond perfect vision"). The public will likely have different attitudes towards different genetic modifications because the social consequences and meanings of different traits are varied. We think the differences in attitudes to different types of genetic modification represents a rich vein of possible future research.

level. In Section IV.A we synthesize the support we found for what has been named "gene doping," in contrast to attitudes towards doping more generally. In Section IV.B and Section IV.C we discuss the evidence we have as to why this difference may exist. In Section IV.D we discuss our result that inequity of access to the technology did not affect response. In Section IV.E we speculate how our results may be consistent with a different concept of the spirit of sport. Finally, in Section IV.F we discuss some limitations of this study.

A. Support for Gene Doping

We found that 54% (physical scenario) and 66% (psychological scenario) agreed or were indifferent to genetic modification for enhancement of athletic performance. These numbers are within the ballpark of recently established figures for overall support for somatic modification for enhancement (65%).[96] This was in stark contrast to the 17% of people who agreed or were indifferent to athletes being allowed to dope. Why the high level of support? We considered and tested two hypotheses.

B. Genetics at Birth Are Not Deserving of Competitive Protection

The first hypothesis was that it is viewed as not fair to protect the genetics one happens to be born with. We have at least three lines of evidence to support this hypothesis.

First, it does not matter whether a genetic advantage comes from birth or a procedure: 79% agreed or were indifferent to our *Origin of Advantage Not Important* statement (*People who have chosen to acquire Gene Z should be permitted to race with people who were born with Gene Z)*. This result suggests that genetic advantages at birth are not seen as entitlements worthy of protection in competition. The corresponding number for the *Psychological Enhancement* scenario was 86%. Indeed, of those people who agreed that the origin of advantage was not important, 67% agreed or were indifferent to the statement *Sports would be a fairer test if the biological playing field were more level*. This result suggests that genetic modification may be seen as a tool to promote equality of opportunity.

Second, drawing attention to the existence of biological differences that affect performance leads to more support for enhancement. For our *Biomolecule* scenarios which differed only in whether or not the exist-

96. The survey of 1600 U.S.-based individuals published in August 2017 found that 65% were in favor of (39%) or indifferent to (26%) somatic modification for enhancement. Schufele et al., *supra* note 11.

ence of natural differences between individuals were mentioned, there was majority support for enhancement in both cases, with even more support if the existence of natural differences was mentioned (63% agreed or indifferent versus 56%, p = 0.05).

Third, respondent approval for enhancement increased with the possibility of choosing to improve our genetics. From our first study, of those who disagreed with our *Allow Modified Athletes* statement*,* 74% supported separate categories. When no possibility of genetic enhancement was mentioned (*No Genetic Enhancement* scenario), 43% supported separate categories of competition (agreed or were indifferent to the *Have Genetic Categories* statement). Thus, we anticipate that as people become more aware of the possibility of changing human genetics, they will be less likely to view the genetics one is born with as worthy of privilege and protection. Our findings echo prior work in other areas finding that individuals' preferences align with minimizing the role of unearned advantage.[97]

A minority of respondents viewed the natural genetic endowment in our scenario as "too much" of an advantage (14% of individuals disagreed with the *Allow Naturally Genetically Advantaged Athletes* statement in the *No Genetic Enhancements* scenario). There is a history of this view. For example, Caster Semenya has dominated the women's sprinting scene when she has been allowed to compete without taking hormone suppressants.[98] A sprinter who has raced alongside Caster, Paula Wright, has said: "I don't like the idea of anyone being excluded . . . but we have to keep our sport fair, which means deciding where the genetic and performance advantage is too much."[99] When Caster won the Women's 800m event at Rio in 2016, Lynsey Sharp, who finished sixth said "[e]veryone can see it's two separate races,"[100] while Polish Joanna Jozwik, who finished fifth, said "I'm glad I'm the first European, the second white."[101] The IOC has acted on these concerns in its attempts to

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97. *See* discussion *supra* Section II.C.

98. *See* Nick Zaccardi, *Caster Semenya on New IAAF Rule: 'Discriminatory, Irrational, Unjustifiable'*, NBC SPORTS (Jun. 18, 2018), https://olympics.nbcsports.com/2018/06/18/caster-semenya-testosterone-rule/ [https://perma.cc/88NR-TA7D] (noting Semenya's dominance and lull in performance corresponding with testosterone-limiting rule).

99. Tim Layden, *Is It Fair for Caster Semenya to Compete Against Women at the Rio Olympics?*, SPORTS ILLUSTRATED (Aug. 11, 2016), http://www.si.com/olympics/2016/08/11/caster-semenya-2016-rio-olympics-track-and-field [https://perma.cc/CJF5-7MT2].

100. Tom Morgan, *Caster Semenya Wins 800m: Beaten GB Finalist Lynsey Sharp Criticises Rule Changes Over 'Obvious' Hyperandrogenous Women*, TELEGRAPH (Aug. 21, 2016, 3:14 PM), http://www.telegraph.co.uk/news/2016/08/21/lynsey-sharp-criticises-obvious-hypoadrogenous-women-having-bein/ [https://perma.cc/TC4B-JQT9].

101. Mark Critchley, *Rio 2016: Fifth-Placed Joanna Jozwik 'Feels Like Silver Medallist' After 800m Defeat to Caster Semenya*, INDEPENDENT (Aug. 22, 2016, 12:15 PM), http://www.independent.co.uk/sport/olympics/rio-2016-joanna-jozwik-caster-semenya-800m-hyperandrogenism-a7203731.html [https://perma.cc/8NVD-UHA9].

force women such as Caster who have naturally elevated testosterone levels to suppress these hormones artificially.[102]

As discussed in the Background,[103] WADA's judgment as to what constitutes cheating relies on the idea of promoting natural talent. When faced with the possibility of genetic modification, our respondents do not necessarily see the promotion of natural talent as fair. They do not see genetic endowments as advantages worthy of competitive protection. Insofar as our respondents do equate promoting natural talents with fairness, we hypothesize that they may be conceiving of natural talents as character-based traits or intangibles. Our hypothetical presents a powerful way in which one conception of fairness, equality of opportunity, can be enhanced — by offsetting the inequities of the natural lottery. Genetic modification in such contexts may prove to be a means of furthering equality of opportunity with the potential for bipartisan support, as a feature of this method is that it is one way of leveling opportunity that does not necessarily require economic resource redistribution.

C. Choice of Language Impacts Public Perception

Our other hypothesis to explain why what WADA calls "gene doping" had a much higher level of support than drug doping was that choice of language had a large impact on public perception. Our data strongly supported this hypothesis. A minority of respondents agreed or were indifferent to allowing athletes to use drugs (29%) while a slight majority agreed or were indifferent to allowing athletes to use biomolecules (56%) ($p < 10^{-5}$) (in response to the *Allow Modified Athletes* state-

102. Before the London 2012 Olympics the IOC declared that it would be testing testosterone levels to determine who was permitted to compete in the female category. *See* INT'L OLYMPIC COMM., *supra* note 65. This approach was abandoned for the Rio Olympics in 2016 following a 2014 ruling by the Court of Arbitration for Sport, partly because of the underlying biological complexity. *See* Talha Khan Burki, *Hyperandrogenism Rule No Longer in Play at Rio Olympics*, 4 LANCET DIABETES & ENDOCRINOLOGY 820, 820 (2016). The case involved additional biological complexity, as high levels of testosterone were acknowledged to only confer an advantage in the presence of working androgen receptors, which many of the athletes in question did not have. *See Chand v. Athletics Fed'n of India*, CAS 2014/A/3759 158, ¶ 547 (Ct. Arb. Sport 2015), http://www.tas-cas.org/fileadmin/user_upload/AWARD_3759__FINAL___REDACTED_FOR_PUBLICATION_.pdf [https://perma.cc/SUJ7-VJVG]. In April 2018, the International Association of Athletics Federations announced the introduction of new eligibility regulations that would require females with hyperandrogenism to artificially suppress their hormone levels in order to compete in certain events. *See IAAF Introduces New Eligibility Regulations for Female Classification,* INT'L ASS'N OF ATHLETICS FED'N (Apr. 26, 2018), https://www.iaaf.org/news/press-release/eligibility-regulations-for-female-classifica [https://perma.cc/8AFN-Q762]. Caster Semenya has challenged this ruling by lodging a request for arbitration with the CAS. *See* Nick Said, *Semenya Challenges IAAF Ruling at Court of Arbitration for Sport*, REUTERS (June 19, 2018, 7:54 AM), https://www.reuters.com/article/us-athletics-semenya-cas/semenya-challenges-iaaf-ruling-at-court-of-arbitration-for-sport-idUSKBN1JF1JJ [https://perma.cc/GFD8-WRJN].

103. *See* discussion *supra* Section II.C.

ment in the *Drug, No Natural Differences* and *Biomolecule, No Natural Differences* scenarios, respectively). This difference highlights the significance of WADA's preemptive move to ban any form of genetic engineering, including the introduction of the term "gene doping." WADA regards educating the public on what doping is and why it is counter to the spirit of sport as central to its mission.[104] WADA's moves to shape the debate contrast with consistent calls to seek public input at such moments when potentially game-changing technology emerges. The National Academies of Sciences and Medicine have made a clear and urgent call for public engagement, on the basis that "[m]eaningful engagement with decision makers and stakeholders promotes transparency, confers legitimacy, and improves policy making."[105] If the public is not primed to think of genetic modification as doping, our data shows support for its use.

D. Inequity of Access Not a Concern

It seems surprising that we found no statistically significant difference in the level of support for the *High Cost* scenario compared to our *Base Case* (low cost) scenario. There are at least three different factors that we think may contribute. The first is that people may view equality of access to sporting success as already intractably subject to cost barriers: increased chances of success are bought by the quality of the coaching, precision diets, the quality of facilities, and the access to a broader team of support staff, all of which are a function of money. Second, any inequality caused by a cost-barrier to purchasing genetic equality parallels the inherent inequality in the genetic lottery itself. In other words, the genetic lottery is already unfair, so it does not matter if genetic modification is unfair as well. And third, U.S.-based individuals are accustomed to living in a society where people can spend their money as they choose. For example, in a pay-to-access healthcare system, high cost is normalized for both necessary and elective procedures.

E. The Self-Authoring Vision of the Spirit of Sport

Our results are consistent with an alternative vision of the spirit of sport. WADA's concept of the spirit of sport is an essentialist view, equating talent worthy of protection with at-birth biological potential.[106]

104. *See WADA Ethics Panel: Guiding Vales in Sport and Anti-Doping*, WORLD ANTI-DOPING AGENCY (Oct. 2017), https://www.wada-ama.org/sites/default/files/resources/files/wada_ethicspanel_setofnorms_oct2017_en.pdf [https://perma.cc/JC8H-JLSQ].

105. *See* NAT'L ACADS. OF SCIS., ENG'G & MED., *supra* note 9, at 4.

106. *See* Bengt Kayser et al., *Current Anti-Doping Policy: A Critical Appraisal*, BMC MED. ETHICS, Mar. 29, 2007, at 1, https://bmcmedethics.biomedcentral.com/track/pdf/10.1186/1472-

Our unfolding understanding of how luck in the genetic lottery shapes our abilities[107] calls this premise into question, as does the prospect of formerly fixed human genetics becoming mutable through new genetic modification technologies. If the alignment between the spirit of sport and natural talent is severed, what replaces it? An alternative vision we have touched on prizes choice or judgment — rather than luck.[108] In this *Self-Authoring* vision, excellence produced through judgment and choice is rewarded, and the rewards for non-choice factors, such as inherited genetic advantage, are minimized.[109]

This Self-Authoring vision of the spirit of sport can accommodate different categories for competition based on comparative physical attributes. Precedent for separate categories already exists at the Olympic level.[110] The case of female hyperandrogenism is an example of the IOC's willingness to use underlying biology to define categories.[111] It may be that in years to come, genetic advantage is added to the list of categorical differentiators.

F. Limitations and Future Directions

Applications of new technologies often have global consequences. The availability of medical tourism means that one country's permissive regulatory regime can limit the effectiveness of more restrictive frameworks implemented in other jurisdictions.[112] There is good reason to expect a diversity of international perspectives on the applications of

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6939-8-2 [https://perma.cc/K2LN-YU6V] (arguing that current anti-doping policy rests on dubious claims as to what is natural or normal); *see also* J. Savulescu et al., *Why We Should Allow Performance Enhancing Drugs in Sport*, 38 BRIT. J. SPORTS MED. 666, 666 (2004) (arguing that the view of sports as finding the person with the most biological potential was "the old naturalistic Athenian vision of sport: find the strongest, fastest, or most skilled man").

107. *See* discussion *supra* Section II.B.

108. *See* discussion *supra* Section II.C.

109. *See* Savulescu et al., *supra* note 106, at 666–67 ("Far from being against the spirit of sport, biological manipulation embodies the human spirit — the capacity to improve ourselves on the basis of reason and judgement . . . . Sport would be less of a genetic lottery.").

110. Most notably there are separate categories for men and women, some with different sub-events and rules. For example, the events that female and male gymnasts compete in are different. *See Gymnastics Artistic*, INT'L OLYMPIC COMM., https://www.olympic.org/gymnastics-artistic [https://perma.cc/C7CP-K2AB]. With some degree of success, biological categories have been created to reflect the diversity of athletes' physical endowments for the Paralympics. *See* INT'L PARALYMPIC COMM., *Classification Introduction*, PARALYMPIC MOVEMENT, https://www.paralympic.org/classification [https://perma.cc/9RJP-3ZJD]. Akin to the genetic case, crisp categorical distinctions often prove elusive in these instances; nevertheless, lines have been drawn which are workable. Factors including muscle tone, short stature, and limb length are all used. *See id.*

111. *See* discussion *supra* note 102.

112. *See* R. Alta Charo, *On the Road (to a Cure?) — Stem-Cell Tourism and Lessons for Gene Editing*, 374 NEW ENG. J. MED. 901, 901 (Mar. 10, 2016).

genome modification. For example, Chinese[113] and Russian[114] citizens may be less concerned about the specter of eugenics than their European and North American counterparts. Specifically, in the case of athletic competition at the international level, a global enterprise involving nation states as well as the private sector, a diverse array of public opinion is relevant.[115]

We designed our study to capture preferences concerning modifications to genetic difference present in the human gene pool. There may additionally be preference differences depending upon how commonly a gene is found in other humans. Professional sports are an interesting test case, because extremes of ability are already the norm. The extension of this work to other domains, for example to education or the military, may reveal different socially meaningful boundaries on which regulation of genetic modification ought to be based.

V. CONCLUSION

Genetic modification, particularly CRISPR, is a game-changing new technology that has the potential to positively impact society in many ways. This impact will be shaped by regulation. Many public bodies have called for urgent interaction with, and assessment of, public attitudes to this powerful new tool. WADA was the first to ban genetic modification as a condition for participation in a valued social domain: sports. This is not surprising as athletes are known to be early adopters of technologies offering a competitive edge. As an early and highly visible mover, WADA's negative attitude may have a disproportionate effect on public perception and regulation in other areas. Indeed, we found that the condemning language of "drugs," in contrast with neutral descriptions of the same underlying substance, influenced public judgments of ethical permissibility. Sports, with its defined rules and clear outcomes, also provides a highly accessible framework for discussing the

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113. *See* Geoffrey Miller, *2013: What *Should* We Be Worried About?*, EDGE (2013), https://www.edge.org/response-detail/23838 [https://perma.cc/FD68-9YB4] (arguing for the importance of Chinese eugenic ambitions).

114. A study found that 40% of Russians and 7% of Britons approve of genetic modification ("changing genes") to enhance "special skills." Lev Gudkov et al., *Human Genetic Improvement: A Comparison of Russian and British Public Perceptions.*, 134 BULL. MED. ETHICS 20 (Jan. 1998). By way of comparison, 55% of Russians and 29% of Britons approve of vitamin supplements for the same purpose. *Id.*

115. Our study is limited in its focus on U.S.-based individuals. Other differences may exist in terms of concerns over equity of access. While we found that our respondents were not influenced by high cost barriers to access, this may be because U.S.-based individuals are used to pay-to-access healthcare. Those who live in societies where this is not the case may think differently.

potential impact of new technologies more broadly.[116] Our study is the first to investigate public preferences for the regulation of genetic enhancement in sports. There are multiple reasons for WADA to consider the preferences of the public. One is that doing so confers legitimacy upon its institutional pronouncements.[117] Another is to protect the economic value of sports, an aim which is furthered by incorporating consumer preferences into its prohibition decisions.[118]

WADA aims to protect the spirit of sport, defined as "the dedicated perfection of each person's natural talents."[119] But even before the advent of genetic modification, relying on this idea was problematic. Because WADA permits many means of bolstering natural endowments (for example, surgeries), naturalness is already being challenged as fair. Another example of WADA's policies being in tension with its dedication to naturalness as fair is WADA's disparate treatment of females with naturally higher levels of testosterone. The prospect of genetic modification may be the death knell for the use of naturalness as an organizing principle. As our results show, the public does not necessarily see the genetics one happens to be born with as worthy of competitive protection. Our results suggest that, at least in the United States, the public's opinion does not align with WADA's on the boundaries of the spirit of sport. WADA could instead adopt a vision of the spirit of sport where athletes are deserving of glory for the choices they make and the self-authorship of their victories. This could be combined with sensible precautions to protect athlete health.[120]

We are currently faced with decisions on how to balance the potential gains of CRISPR against threats, perceived or otherwise. Our data reflect increased acceptance of genetic modification, which raises questions about the necessity of a blanket prohibition in the case of sports. This increased acceptance illustrates an opportunity to implement more narrowly-tailored and evidence-based regulatory approaches. Our findings are consistent with distributive justice perspectives that consider a fair system to be one in which the role of unearned advantages, notably

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116. *See, e.g.*, W. Miller Brown, *The Case for Perfection*, 36 J. PHIL. SPORT 127 (2009) ("[S]ports are both a catalyst for such discussion and a social microcosm, a kind of laboratory, where the impact of biotechnology is publicly visible and practically displayed.").

117. *See, e.g.*, JOHN RAWLS, POLITICAL LIBERALISM 137 (1993) ("[O]ur exercise of political power is fully proper only when it is exercised in accordance with a constitution the essentials of which all citizens as free and equal may reasonably be expected to endorse in the light of principles and ideals acceptable to their common human reason.")

118. *See* Posner, *supra* note 77, at 1734.

119. 2015 WADA CODE, *supra* note 56, at 14.

120. *See* Savulescu et al., *supra* note 106, at 668 (encouraging a focus on safety rather than prohibition as part of his argument for allowing doping in general in sports). A similar focus for genetic modification in particular could perhaps be developed in a consistent way to protect athlete health. *See id.*

birth endowments, are minimized, and in which individuals are rewarded based on their efforts and ambitions as expressed through their choices.[121] Genetic privileges are just one of the many inherited privileges, both social and biological, of which one can be a beneficiary. Inherited privileges have long gated access to positions and goods valued by society, and in many cases these gates have collapsed alongside changing public opinion, e.g. women's rights. Genetic privilege may also be so challenged — particularly in a world where we both understand how particular genetic differences lead to advantages, and where those differences can become unshackled from the roll of the dice at birth.

121. *See* discussion *supra* Section II.C. We suspect that some of our readers may view the prospect of genetic modification as a *reductio ad absurdum* on the luck egalitarianism theory, even if it is a theory that coheres with individual preferences.

APPENDIX I

Genetic variation in several genes is relevant to gaining a performance edge in sports. There is a high overlap between these genes and those that are targets for gene therapy.

Table 1: Genes Related to Performance Enhancement in Sports, and Their Strong Overlap with Targets for Gene Therapy

Gene	**Role of Gene**	**Example genetic variation**	**Work related to gene therapy**
EPOR	Determines red blood cell count[122]	Variant that enables blood to carry more oxygen[123]	Animal studies motivated by treatment for anemia associated with chronic renal failure and thalassemia[124]
COL5A1	Part of collagen, the main component of connective tissue[125]	Variant associated with likelihood of Achilles tendon injuries[126]	
SLC6A4	Control of serotonin levels[127]	Variant that produces more serotonin more common in athletes than non-athletes[128]	

122. *See* Chapelle et al., *supra* note 35, at 4495.
123. *See id.* at 4498.
124. *See* S. Zhou et al., *Adeno-Associated Virus-Mediated Delivery of Erythropoietin Leads to Sustained Elevation of Hematocrit in Nonhuman Primates*, 5 GENE THERAPY 665, 665 (1998).
125. *See* G. G. Mokone et al., *The COL5A1 Gene and Achilles Tendon Pathology*, 16 SCANDINAVIAN J. MED. & SCI. SPORTS 19, 19 (2006).
126. *See id.*
127. *See* E.V. Trushkin et al., *Association of SLC6A4 Gene 5-HTTLPR Polymorphism with Parameters of Simple and Complex Reaction Times and Critical Flicker Frequency Threshold in Athletes During Exhaustive Exercise*, 150 BULL. EXPERIMENTAL BIOLOGY & MED. 471, 471 (2011).
128. *See id.*

Gene	Role of Gene	Example genetic variation	Work related to gene therapy
VEGF	Involved in growing new blood vessels[129]	Variant that gives higher oxygen uptake before and after aerobic training[130]	Human trials for treatment of chronic critical leg ischemia[131]
IGF	Involved in muscle repair and growth[132]	Genetic variation associated with more of this gene product is more common in power athletes[133]	Animal studies to demonstrate utility for those recovering from injury and for the elderly[134]
PPAR	A regulator of metabolism[135]	Genetic variant associated with endurance performance[136]	Animal studies for treatment of atherosclerosis[137]
BDNF	Involved in neural development[138]	Variants that affect psychological response to stress and motivation to exercise[139]	Animal studies motivated by improving progression of Huntington's disease[140]

129. *See* Steven J. Prior et al., *DNA Sequence Variation in the Promoter Region of the VEGF Gene Impacts VEGF Gene Expression and Maximal Oxygen Consumption*, 290 AM. J. OF PHYSIOLOGY-HEART & CIRCULATORY PHYSIOLOGY H1848, H1848 (2005), http://ajpheart.physiology.org/content/290/5/H1848.full.pdf+html.

130. *See id.*

131. *See* Kou-Gi Shyu et al., *Intramuscular Vascular Endothelial Growth Factor Gene Therapy in Patients with Chronic Critical Leg ischemia*, 114 AM. J. MED. 85, 85 (2003).

132. *See* Sigal Ben-Zaken et al., *Can IGF-I Polymorphism Affect Power and Endurance Athletic Performance?*, 23 GROWTH HORMONE & IGF RES. 175, 175 (2013).

133. *See id.*

134. *See* Sukho Lee et al., *Viral Expression of Insulin-Like Growth Factor-I Enhances Muscle Hypertrophy in Resistance-Trained Rats*, 96 J. APPLIED PHYSIOLOGY 1097, 1097 (2003), https://www.physiology.org/doi/pdf/10.1152/japplphysiol.00479.2003.

135. *See* I.I. Ahmetov et al., *Association of a PPARD Polymorphism with Human Physical Performance*, 41 MOLECULAR BIOLOGY 776, 776 (2007).

136. *See id.*; Vihang A. Narkar et al., *AMPK and PPARδ Agonists are Exercise Mimetics*, 134 CELL 405, 405 (2008).

137. *See* G. Li et al., *Hematopoietic Knockdown of PPARδ Reduces Atherosclerosis in LDLR−/− Mice*, 23 GENE THERAPY 78, 78 (2016).

138. *See* A. Pokrwka et al., *Genes in Sport and Doping*, 30 BIOLOGY SPORT 155, 158 (2013).

139. *See id.*; *see also* Muaz Belviranli et al., *The Relationship Between Brain-Derived Neurotrophic Factor, Irisin and Cognitive Skills of Endurance Athletes*, 44 PHYSICIAN & SPORTS MED. 290, 290 (2016).

140. *See* B. Connor et al., *AAV1/2-Mediated BDNF Gene Therapy in a Transgenic Rat Model of Huntington's Disease*, 23 GENE THERAPY 283, 283 (2016); *see also* H. Fukui et al., *BDNF Gene Therapy Induces Auditory Nerve Survival and Fiber Sprouting in Deaf Pou4f3 Mutant Mice*, SCI. REP., Nov. 12, 2016, at 1, https://www.nature.com/articles/srep00838.pdf [https://perma.cc/P6NT-WG5S].

Gene	Role of Gene	Example genetic variation	Work related to gene therapy
MSTN	Myostatin; inhibits muscle differentiation and growth[141]	Variants that reduce levels of myostatin lead to muscle growth[142]	Animal studies and human trials for those with muscle diseases and as a protection against muscle loss with age [143]
ACTN3	Component of the contractile apparatus in fast skeletal muscle fibers[144]	Elite sprinters are more likely to carry a certain variant[145]	
HBB	Haemoglobin; enables blood to carry oxygen[146]	Variants that affect cardiorespiratory adaptation[147]	Animal studies and human trials for treatment of β-Thalassemia[148]

141. *See* Markus Schuelke et al., *Myostatin Mutation Associated with Gross Muscle Hypertrophy in a Child*, 350 NEW ENG. J. MED. 2682, 2682 (2004).

142. *See id.*

143. *See Dual Gene Therapy Has Beneficial Effects on Blood Biomarkers and Muscle Composition*, BIOVIVA (Mar. 21 2018), http://bioviva-science.com/blog/dual-gene-therapy-has-beneficial-effects-on-blood-biomarkers-and-muscle-composition [https://perma.cc/YQ6U-39EW]; Janaiah Kota et al., *Follistatin Gene Delivery Enhances Muscle Growth and Strength in Nonhuman Primates*, 1 SCI. TRANSLATIONAL MED. 1, 1–2 (2009) (examining Follistatin in the same pathway).

144. *See* Nan Yang et al., *ACTN3 Genotype Is Associated with Human Elite Athletic Performance*, 73 AM. J. HUMAN GENETICS 627, 628 (2003).

145. *See id.* at 627.

146. *See* Z. He et al., *Polymorphisms in the HBB Gene Relate to Individual Cardiorespiratory Adaptation in Response to Endurance Training*, 40 BRIT. J. SPORTS MED. 998, 998 (2006).

147. *See id.*

148. *See* Zhanhui Ou et al., *The Combination of CRISPR/Cas9 and iPSC Technologies in the Gene Therapy of Human β-Thalassemia in Mice*, 6 SCI. REP. 1, 1 (2016).