Exhibit A

LAWRENCE G. WASDEN
ATTORNEY GENERAL

STEVEN L. OLSEN, ISB #3586
W. SCOTT ZANZIG, ISB #9361
DAYTON P. REED, ISB #10775
Deputy Attorneys General
954 W Jefferson, 2nd Floor
P. O. Box 83720
Boise, ID 83720-0010
Telephone: (208) 334-2400
Facsimile: (208) 854-8073
steven.olsen@ag.idaho.gov
scott.zanzig@ag.idaho.gov
dayton.reed@ag.idaho.gov

Attorneys for Defendants

IN THE UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF IDAHO

LINDSAY HECOX, and JANE DOE with her next friends JEAN DOE and JOHN DOE, Plaintiffs, v. BRADLEY LITTLE, in his official capacity as Governor of the State of Idaho, *et al.*, Defendants.	Case No. 1:20-cv-00184-DCN **EXPERT DECLARATION OF GREGORY A. BROWN, Ph.D. FACSM**

I, Dr. Gregory A. Brown, declare as follows:

Qualifications

1. I serve as Professor of Exercise Science in the Department of Kinesiology and Sport Sciences at the University of Nebraska Kearney. I have served as a tenured (and non-tenured) professor at universities since 2002.

2. I teach classes in Exercise Physiology and in Research Methods. I have previously taught courses in Human Anatomy & Physiology and in Sports Nutrition.

3. In August 2002, I received a Doctor of Philosophy degree from Iowa State University, where I majored in Health and Human Performance, with an emphasis in the Biological Bases of Physical Activity. In May 1999, I received a Master of Science degree from Iowa State University, where I majored in Exercise and Sport Science, with an emphasis in Exercise Physiology.

4. I have received many awards over the years, including the Mortar Board Faculty Excellence Honors Award, College of Education Outstanding Scholarship / Research Award, and the College of Education Award for Faculty Mentoring of Undergraduate Student Research.

5. I have authored more than 40 refereed publications and more than 50 refereed presentations in the field of Exercise Science. And I have served as a peer reviewer for over 25 professional journals, including The American Journal of Physiology, the International Journal of Exercise Science, the Journal of Strength and Conditioning Research, and The Journal of Applied Physiology.

6. My areas of research have included the endocrine response to testosterone prohormone supplements in men and women, the effects of testosterone prohormone supplements on health and the adaptations to strength training in men, the effects of energy drinks on the physiological response to exercise, and assessment of various athletic training modes in males and females. Articles that I have published that are closely related to topics that I discuss in this declaration, and to articles by other researchers that I cite and discuss in this declaration, include:

a. Studies of the effect of ingestion of a testosterone precursor on circulating testosterone levels in young men. Douglas S. King, Rick L. Sharp, Matthew D. Vukovich, Gregory A. Brown, et al., *Effect of Oral Androstenedione on Serum Testosterone and Adaptations to Resistance Training in Young Men: A Randomized Controlled Trial*, JAMA 281: 2020-2028 (1999); G. A. Brown, M. A. Vukovich, et al., *Effects of Anabolic Precursors on Serum Testosterone Concentrations and Adaptations to Resistance Training in Young Men*, INT J SPORT NUTR EXERC METAB 10: 340-359 (2000).

b. A study of the effect of ingestion of that same testosterone precursor on circulating testosterone levels in young women. G. A. Brown, J. C. Dewey, et al., *Changes in Serum Testosterone and Estradiol Concentrations Following Acute Androstenedione Ingestion in Young Women*, HORM METAB RES 36: 62-66 (2004).

c. A study finding (among other things) that body height, body mass, vertical jump height, maximal oxygen consumption, and leg press maximal strength were higher in a group of physically active men than comparably active women, while the women had higher percent body fat. G. A. Brown, Michael W. Ray, et al., *Oxygen Consumption, Heart Rate, and Blood Lactate Responses to an Acute Bout of Plyometric Depth Jumps in College-Aged Men And Women*, J. STRENGTH COND RES 24: 2475-2482 (2010).

d. A study finding (among other things) that height, body mass, and maximal oxygen consumption were higher in a group of male NCAA Division 2 distance runners, while women NCAA Division 2 distance runners had higher percent body fat. Furthermore, these male athletes had a faster mean competitive running speed (~3.44 min/km) than women (~3.88 km/min), even though the men ran 10 km while the women ran 6 km. Katherine Semin, Alvah C. Stahlnecker, Kate A. Heelan, G. A. Brown, et al,

Discrepancy Between Training, Competition and Laboratory Measures of Maximum Heart Rate in NCAA Division 2 Distance Runners, JOURNAL OF SPORTS SCIENCE AND MEDICINE 7: 455-460 (2008).

7. I attach a copy of my current Professional Vita, which lists my education, appointments, publications, research, and other professional experience. I am also currently providing expert information on a case similar to this one in the state of Connecticut.

8. I have been asked by counsel for defendants in the matter of *Hecox et al. v. Little et al.* to offer my opinions about whether males have inherent advantages in athletic performance over females, and if so the scale and physiological basis of those advantages, to the extent currently understood by science. I have also been asked to offer my opinion as to whether the sex-based performance advantage enjoyed by males is eliminated if feminizing hormones are administered to male athletes who identify as transgender.

9. The opinions in this declaration are my own, and do not necessarily reflect the opinions of my employer, the University of Nebraska.

10. I have been compensated for my time spent in preparing this declaration at the rate of $150 per hour, and may be further compensated for time spent in subsequent testimony in this action.

Overview

11. Based on my professional familiarity with exercise physiology and my review of the currently available science, including that contained in the sources I cite in this declaration, and the competition results and records presented here, I offer three primary professional opinions:

a. At the level of elite, college, high school, and recreational competition, men or boys have an advantage over comparably aged women or girls, in almost all athletic contests;

b. Biological male physiology and anatomy is the basis for the performance advantage that men or boys have over women or girls, in almost all athletic contests; and

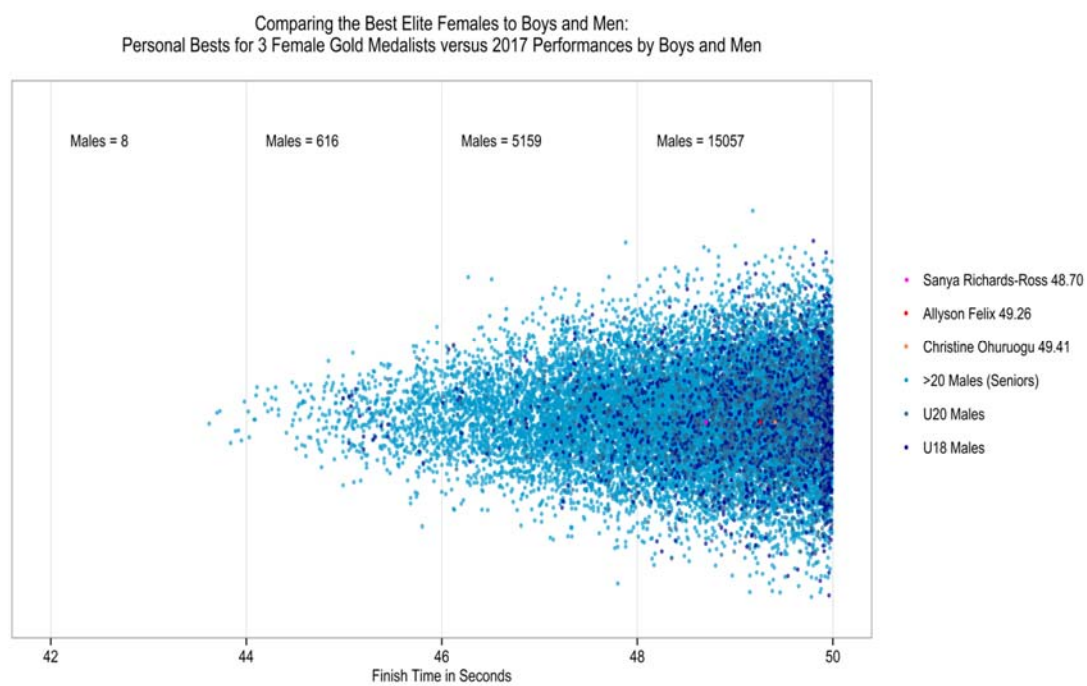
c. Administration of androgen inhibitors and cross-sex hormones to men, or adolescent boys, after male puberty, and administration of testosterone to women or adolescent girls, after female puberty, does not eliminate the performance advantage of men or adolescent boys over women or adolescent girls in almost all athletic contests.

In this declaration, I also provide supporting details, facts, and opinions relating to each of these primary opinions . Each of these opinions is based on my general professional expertise and experience, as well as on particular academic articles, and the competition results and records, that I refer to herein.

12. In short summary, men, and adolescent boys, perform better in almost all sports than women, and adolescent girls, because of their inherent physiological advantages that develop during male puberty. In general, men, and adolescent boys, can run faster, output more physical power, jump higher, and exercise greater physical endurance than women, and adolescent girls.

13. Indeed, while after the onset of puberty males are on average taller and heavier than females, a male performance advantage over females has been measured in weightlifting competitions even between males and females matched for body mass.

14. These performance advantages are also very substantial, such that large numbers of men and even adolescent boys are able to outperform the very top-performing women. To illustrate, Doriane Coleman, Jeff Wald, Wickliffe Shreve, and Richard Clark created the figure below (last accessed on Monday, December 23, 2019 at https://bit.ly/35yOyS4), which shows that the *lifetime best performances* of three female Olympic champions in the 400m event—including Team USA's Sanya Richards-Ross and Allyson Felix—would not match the performances of literally thousands of boys and men, *just in 2017 alone*, including many who would not be considered top tier male performers:



15. Coleman and Shreve also created the table below (last accessed on Monday, December 23, 2019 at https://bit.ly/37E1s2X), which "compares the number of boys—males under the age of 18—whose results in each event in 2017 would rank them above the single very best elite [adult] woman that year:"

TABLE 1 – World's Best Woman v. Under 18 Boys			
Event	Best Women's Result	Best Boys' Result	# of Boys Outperforming
100 Meters	10.71	10.15	124+
200 Meters	21.77	20.51	182
400 Meters	49.46	45.38	285
800 Meters	1:55.16*	1:46.3	201+
1500 Meters	3:56.14	3:37.43	101+
3000 Meters	8:23.14	7:38.90	30
5000 Meters	14:18.37	12:55.58	15
High Jump	2.06 meters	2.25 meters	28
Pole Vault	4.91 meters	5.31 meters	10
Long Jump	7.13 meters	7.88 meters	74
Triple Jump	14.96 meters	17.30 meters	47

16. Coleman and Shreve also created the table below (last accessed on Monday, December 23, 2019 at https://bit.ly/37E1s2X), which compares the number of men—males over 18—whose results in each event in 2017 would have ranked them above the very best elite woman that year.

TABLE 2 – World's Best Woman v. Number of Men Outperforming			
Event	Best Women's Result	Best Men's Result	# of Men Outperforming
100 Meters	10.71	9.69	2,474
200 Meters	21.77	19.77	2,920
400 Meters	49.46	43.62	4,341
800 Meters	1:55.16*	1:43.10	3,992+
1500 Meters	3:56.14	3:28.80	3,216+
3000 Meters	8:23.14	7:28.73	1307+
5000 Meters	14:18.37	12:55.23	1,243
High Jump	2.06 meters	2.40 meters	777
Pole Vault	4.91 meters	6.00 meters	684
Long Jump	7.13 meters	8.65 meters	1,652
Triple Jump	14.96 meters	18.11 meters	969

17. These advantages result, in large part (but not exclusively), from higher testosterone concentrations in men, and adolescent boys, after the onset of male puberty. Higher testosterone levels cause men, and adolescent boys, to develop more muscle mass, greater muscle strength, less body fat, higher bone mineral density, greater bone strength, higher hemoglobin concentrations, larger hearts and larger coronary blood vessels, and larger overall statures than women, and adolescent girls. In addition, maximal oxygen consumption (VO_2max), which correlates to ~30-40% of success in endurance sports, is higher in both elite and average men and boys than in comparable women and girls when measured in regards to absolute volume of oxygen consumed and when measured relative to body mass. Testosterone is also associated with increased aggressiveness, which may offer competitive advantages for men over women.

18. Although androgen deprivation may modestly decrease some physiological advantages that men and adolescent boys have over women and adolescent girls, it cannot fully eliminate those physiological advantages once an individual has passed through male puberty. For example, androgen deprivation does not reduce bone size, does not alter bone structure, and does not decrease lung volume or heart size. Nor does androgen deprivation in adult men completely reverse the increased muscle mass acquired during male puberty.

19. In this declaration, I present, in the headings marked with Roman numerals, certain of my opinions about sex-based differences in human physiology and the impact of those differences on the athletic performance of men and women. For each of these opinions, I then provide a brief overview, and a non-exhaustive summary of studies published in science journals or other respected sources that support and provide in part the basis of my opinion, also quoting relevant findings of each article.

20. In particular, in addition to the article by Coleman and Schreve that I discuss above, I cite twenty-two articles published in scientific journals. I provide capsule summaries of those articles below. These studies form part of the basis of the opinions I set forth in this declaration, which are also informed by my general professional expertise and experience. In support of the opinions I offer, I expect to explain and testify concerning the findings and conclusions of these articles that I detail in this declaration. I expect to use any or all of the tables and charts that I have reproduced in this declaration, as well as any other tables or charts contained in the articles I reference, to present and explain my opinions to the court.

a. The first resource I cite is David J. Handelsman, Angelica L. Hirschberg, et al., *Circulating Testosterone as the Hormonal Basis of Sex Differences in Athletic Performance*, 39:5 ENDOCRINE REVIEWS 803 (2018). This article correlates data about performance differences between males and females with data from over 15 liquid chromatography-mass spectrometry studies of circulating testosterone in adults, as a function of age. The authors conclude, among other things, that "[f]rom male puberty onward, the sex difference in athletic performance emerges as circulating concentrations rise as the testes produce 30 times more testosterone than before puberty, resulting in men having 15- to 20-fold greater circulating testosterone than children or women at any age." (804)

b. The second resource I cite is Valérie Thibault, Marion Guillaume, et al., *Women & Men in Sport Performance: The Gender Gap Has Not Evolved Since 1983*, 9 J. OF SPORTS SCIENCE & MEDICINE 214 (2010). This article analyzes results from 82 athletic events since the beginning of the modern Olympic era, and concludes in part that while a wide sex-based performance gap existed before 1983, due to a likely combination

of physiological and non-physiological reasons, the sex-based performance gap stabilized in 1983, at a mean difference of 10.0 % ± 2.94 between men and women for all events. (214)

c. The third resource I cite is Beat Knechtle, Pantelis T. Nikolaidis, et al., *World Single Age Records in Running from 5 km to Marathon*, 9 FRONTIERS IN PSYCHOLOGY 1 (2013). This article analyzes results from a study of the relationship between performance and age in races of several lengths, and reports in part that "[i]n all races [studied], women were significantly slower than men." (7)

d. The fourth resource I cite is Romuald Lepers, Beat Knechtle, et al., *Trends in Triathlon Performance: Effects of Sex & Age*, 43 SPORTS MED 851 (2013). This article analyzes results from various triathlon events over the course of about 15 years, and reports in part a sex-based performance gap between the sexes of no less than 10% in every component event, with this sex-based performance gap increasing with age.

e. The fifth resource I cite is Espen Tønnessen, Ida Siobhan Svendsen, et al., *Performance Development in Adolescent Track & Field Athletes According to Age, Sex, and Sport Discipline*, 10:6 PLOS ONE 1 (2015). This article analyzes the 100 all-time best Norwegian male and female track and field results (in persons aged 11 to 18) from the 60m and 800m races, and the long jump and high jump events. The results show that sex-specific differences that arise during puberty significantly affect event results, with males regularly outperforming females after age 12.

f. The sixth resource I cite is David J. Handelsman, *Sex Differences in Athletic Performance Emerge Coinciding with the Onset of Male Puberty*, 87 CLINICAL ENDOCRINOLOGY 68 (2017). This article analyzes results from a secondary quantitative

analysis of four published sources that report performance measures in swimming meets, track and field events, and hand-grip strength. The results show in part that the onset and tempo of sex-based performance divergence were very similar for all performance measures, and that this divergence closely paralleled the rise of circulating testosterone in adolescent boys.

g. The seventh article I cite is Moran Gershoni & Shmuel Pietrokovski, *The landscape of sex-differential transcriptome and its consequent selection in human adults*, 15 BMC BIOL 7 (2017). This article details the results of an evaluation of the differences in genetic expression between men and women. The results show that in humans, out of 18,670 protein coding genes that were evaluated, over 6,500 are differentially expressed based on the sex of the person. The main relevance of this article to the case at hand is to help illustrate that the differences between males and females cannot be eliminated by reducing testosterone and increasing estrogen concentrations in a biological male.

h. The eighth article I cite is K. M. Haizlip, et al., *Sex-based differences in skeletal muscle kinetics and fiber-type composition*, 30 PHYSIOLOGY (BETHESDA) 30 (2015). This is a review article summarizing the findings of 56 other articles evaluating the differential expression of genes in skeletal muscles in males and females and how these differences in gene expression influence (among many things) muscle mass, muscle fiber type, and muscle function. The main relevance of this article to the case at hand is to help illustrate that the current scientific evidence indicates that the genetic differences in skeletal muscle size and function between males and females that give males an

athletic performance advantage cannot be eliminated by reducing testosterone and increasing estrogen concentrations in a biological male.

i. The ninth, tenth, and eleventh resources I cite are Konstantinos D. Tambalis, et al., *Physical fitness normative values for 6-18-year-old Greek boys and girls, using the empirical distribution and the lambda, mu, and sigma statistical method*, 16 EUR J SPORT SCI 736 (2016). Mark J. Catley & G. R. Tomkinson, *Normative health-related fitness values for children: analysis of 85347 test results on 9-17-year-old Australians since 1985*, 47 BR J SPORTS MED 98 (2013).Grant R. Tomkinson, et al., *European normative values for physical fitness in children and adolescents aged 9-17 years: results from 2 779 165 Eurofit performances representing 30 countries*, 52 BR J SPORTS MED 1445 (2018). Individually and combined these articles illustrate that boys as young as six years old perform better than comparable age matched girls in health related measures of physical fitness including strength, speed, endurance, and jumping ability. These advantages in health related measures of fitness translate to improved athletic performance in boys when compared to girls likely before and certainly during and after puberty.

j. The twelfth and thirteenth resources I cite are Daniel M. Fessler, et al., *Sexual dimorphism in foot length proportionate to stature*, 32 ANN HUM BIOL 44 (2005). Roshna E. Wunderlich & P. R. Cavanagh, *Gender differences in adult foot shape: implications for shoe design*, 33 MED SCI SPORTS EXERC 605 (2001). These articles evaluate and describe the differences in the feet of men and women, particularly noting that the differences between the sexes are not just a matter of stature but also include morphological traits that can influence runner performance.

k. The fourteenth, fifteenth, and sixteenth resources I cite are Daichi Tomita, et al., *A pilot study on the importance of forefoot bone length in male 400-m sprinters: is there a key morphological factor for superior long sprint performance?,* 11 BMC RES NOTES 583 (2018). Hiromasa Ueno, et al., *The Potential Relationship Between Leg Bone Length and Running Performance in Well-Trained Endurance Runners*, 70 J HUM KINET 165 (2019). Hiromasa Ueno, et al., *Association between Forefoot Bone Length and Performance in Male Endurance Runners*, 39 INT J SPORTS MED 275 (2018). Building upon the information from Fessler (2005) and Wunderlich (2001), these studies collectively illustrate that the length of the bones in the foot and lower leg can contribute to successful competitive running performance, which likely gives men a performance advantage over women in running due to the differences in lower limb sizes described by Fessler et al. (2005) and Wunderlich and Cavanaugh (2001).

l. The seventeenth resource I cite is Louis Gooren, *The Significance of Testosterone for Fair Participation of the Female Sex in Competitive Sports*, 13 ASIAN J. OF ANDROLOGY 653 (2011). This article highlights specific research that indicates pubertal testosterone increases result in significant physiological advantages for men and adolescent boys, compared to women and adolescent girls, after the onset of male puberty.

m. The eighteenth resource I cite is Taryn Knox, Lynley C. Anderson, et al., *Transwomen in Elite Sport: Scientific & Ethical Considerations*, 45 J. MED ETHICS 395 (2019). This article confirms from available science that higher testosterone levels provide an all-purpose benefit in sport, and that the current International Olympic Guidelines rule requiring males who identify as transgender to keep testosterone levels

under 10 nmol/L for one year does not eliminate (or even come close to eliminating) the performance advantage of their male physiology.

n. The nineteenth resource I cite is Louis J. G. Gooren & Mathijs C. M. Bunck, *Transsexuals & Competitive Sports*, 151 EUROPEAN J. OF ENDOCRINOLOGY 425 (2004). This article analyzes results from a study that compared pretreatment physiological measurements in 17 female-to-male transsexuals with the measurements after one year of cross-sexual treatment in 19 male-to-female transsexuals undergoing sex reassignment therapy. The results in part confirmed that androgen deprivation in male-to-female transsexuals decreases muscle mass to some extent but does not eliminate the male muscular advantage and does not reverse certain other effects of androgenization that had occurred during male puberty.

o. The twentieth resource I cite is Anna Wiik et al., *Muscle Strength, Size, and Composition Following 12 Months of Gender-affirming Treatment in Transgender Individuals*, J. CLIN. METAB., 105(3):e805-e813 (2020). This article analyzes the impact of (a) suppression of endogenous hormones and (b) hormone replacement therapy on metrics of transgender individuals including strength, muscle size, and radiological density. After 12 months, strength in male-to-female subjects did not decrease, and muscle volume remained higher in male-to-female subjects than in female-to-male subjects after the latter subjects had undergone 12 months of testosterone injections.

p. The twenty-first resource I cite is Miranda Scharff et al., *Change in Grip Strength in Trans People and Its Association with Lean Body Mass and Bone Density*, ENDOCRINE CONNECTIONS (2019) 8, 1020-1028. This article measured grip strength and multiple parameters of lean body mass and bone density in both male-to-female and

female-to-male populations across their first year of hormone therapy. After 12 months, "the median grip strength in [male-to-female] subjects still [fell] into the 95th percentile for age-matched females."

q. The twenty-second resource I cite is Johanna Harper. *Race Times for Transgender Athletes.* J Sporting Cultures and Identities 6 (2019) 1. This article is oft cited as evidence supporting a lack of performance advantage for male-to-female transgender athletes. Herein I provide a critique of the methodological shortcomings of this study for the purpose of demonstrating the extreme lack of scientific validity or reliability of the results.

21. I explain my opinions and the results of these studies in more detail below.

Opinions

I. Biological men or boys have an advantage over women or girls, in almost all athletic contests.

22. As one team of researchers has recently written, "Virtually all elite sports are segregated into male and female competitions. The main justification is to allow women a chance to win, as women have major disadvantages against men who are, on average, taller, stronger, and faster and have greater endurance due to their larger, stronger, muscles and bones as well as a higher circulating hemoglobin level." David J. Handelsman, Angelic L. Hirschberg, et al., *Circulating Testosterone as the Hormonal Basis of Sex Differences in Athletic Performance*, 39:5 ENDOCRINE REVIEWS 803 (2018).

23. In fact, biological men, and adolescent boys, substantially outperform comparably aged women, and adolescent girls, in competitions involving running speed, swimming speed, cycling speed, jumping height, jumping distance, and strength (to name a few, but not all, of the

performance differences). These performance advantages for men, and adolescent boys, are inherent to the biological differences between the sexes and are not due to social or cultural factors, as evidenced by minimal to no change in the percentage differences between males and females in world class and record setting performances in the past 40 years. In addition, a number of studies indicate that males' athletic advantages over females begin before puberty, and may be apparent as early as six years of age.

24. I highlight below key findings about male performance advantages from eighteen studies or datasets.

A. David J. Handelsman, Angelica L. Hirschberg, et al., *Circulating Testosterone as the Hormonal Basis of Sex Differences in Athletic Performance,* 39:5 ENDOCRINE REVIEWS 803 (2018):

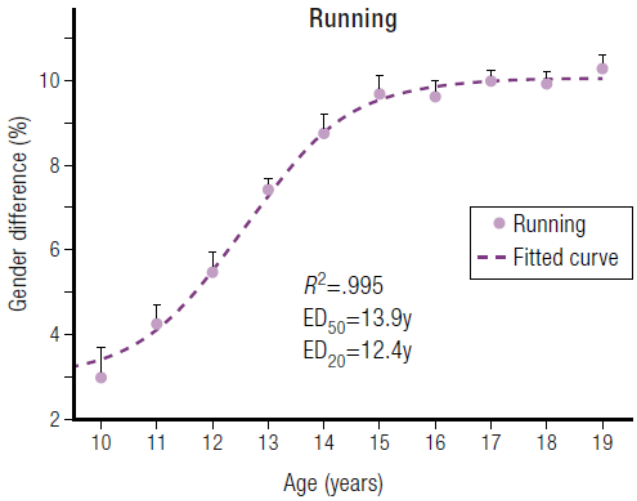
25. The Handelsman et al. (2018) authors demonstrate a consistent pattern of divergence of athletic performance, in favor of males, across the years of puberty and strongly correlating to increasing testosterone levels in adolescent males. The pattern is observed in events exercising a variety of muscle systems. In sum, the Handelsman et al. (2018) authors report: "Corresponding to the endogenous circulating testosterone increasing in males after puberty to 15 to 20 nmol/L (sharply diverging from the circulating levels that remain <2 nmol/L in females), male athletic performances go from being equal on average to those of age-matched females to 10% to 20% better in running and swimming events, and 20% better in jumping events." (812)

/ / /

/ / /

/ / /

26. Taken from Handelsman's Figure 1, the chart below indicates "sex differences in performance (in percentage) according to age (in years) in running events, including 50m to 2 miles." (813)



27. Taken from Handelsman's Figure 1, the chart below indicates "sex differences in performance (in percentage) according to age (in years) … in jumping events, including high jump, pole vault, triple jump, long jump, and standing jump." (813)

28. Taken from Handelsman's Figure 1, the chart below indicates "a fitted sigmoidal curve plot of sex differences in performance (in percentage) according to age (in years) in running, jumping, and swimming events, as well as the rising serum testosterone concentrations from a large dataset of serum testosterone of males. Note that in the same dataset, female serum testosterone concentrations did not change over those ages, remaining the same as in prepubertal

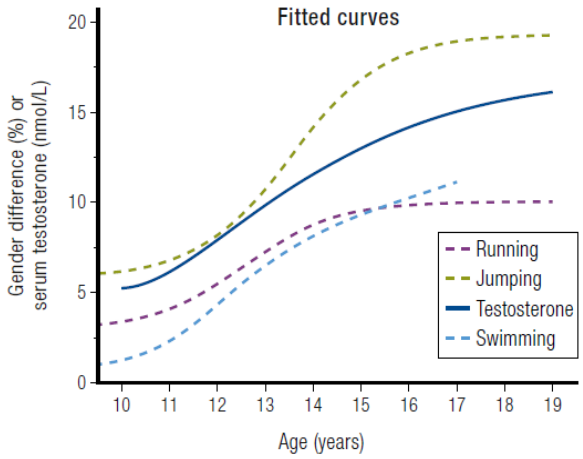
/ / /

/ / /

/ / /

/ / /

boys and girls. Data are shown as mean and SEM of the pooled sex differences by age." (813)



29. These authors also note the significance, for athletic competition, of the subjective nature of "gender identity" in current understanding: "Prompted by biological, personal, and societal factors, volitional expression of gender can take on virtually any form limited only by the imagination, with some individuals asserting they have not just a single natal gender but two genders, none, a distinct third gender, or gender that varies (fluidly) from time to time…." For this reason, the authors conclude: "[I]f gender identity were the basis for eligibility for female sports, an athlete could conceivably be eligible to compete at the same Olympics in both female and male events. These features render the unassailable personal assertion of gender identity incapable of forming a fair, consistent sex classification in elite sports." (804)

B. Valérie Thibault, Marion Guillaume, et al., *Women & Men in Sport Performance: The Gender Gap has not Evolved Since 1983*, 9 J. OF SPORTS SCIENCE & MEDICINE 214 (2010):

30. The Thibault et al. (2010) authors note that there was a large but narrowing sex-based performance gap between men's and women's Olympic athletic performances before 1983, which could hypothetically be attributed to a combination of social, political, or other non-physiological reasons, in addition to physiological reasons. However, "the gender gap in

Olympic sport performance has been stable since 1983" (219) "at a mean difference of 10.0% ± 2.94 between men and women for all [Olympic] events." (222)

31. Since then, even when performances improve, the "progressions are proportional for each gender." (219-20)

32. The results of this study "suggest that women's performances at the high level will never match those of men" (219) and that "women will not run, jump, swim or ride as fast as men." (222) The authors conclude that this gap, now stable for 30+ years, is likely attributable to physiology, and thus that "[s]ex is a major factor influencing best performances and world records." (222)

33. Breaking these performance advantages out by event, the authors report the following sex-based performance gaps in Olympic sport competitions since 1983:

a. "The gender gap ranges from 5.5% (800-m freestyle, swimming) to 36.8% (weightlifting)." (222)

b. Olympic world records in running events indicate that men perform "10.7% (± 1.85)" better than women since gender gap stabilization. (217)

c. Olympic world records in jumping events indicate that men perform "17.5% (± 1.11)" better than women since gender gap stabilization. (217)

d. Olympic world records in swimming events indicate that men perform "8.9 % (± 1.54)" better than women since gender gap stabilization. (218)

e. Olympic world records in cycling sprint events indicate that men perform "6.95% (± 0.16)" better than women since gender gap stabilization. (219)

f. Olympic world records in weightlifting events indicate that men perform "36.8% (± 6.2)" better than women since gender gap stabilization. Note that the

Olympics first introduced women's weightlifting events in 1998, and "no breakpoint date has been detected yet." (219)

34. "The top ten performers' analysis reveals a similar gender gap trend with a stabilization in 1982 at 11.7%" when averaged across all events. (222)

C. Beat Knechtle, Pantelis T. Nikolaidis, et al., *World Single Age Records in Running from 5 km to Marathon*, 9 FRONTIERS IN PSYCHOLOGY 1 (2013):

35. A comparison of performances in races of a variety of distances showed that "[i]n all races, women were significantly slower than men. The estimated sex differences … were increasing" as race distances increased from 8 km.[1]

D. Romuald Lepers, Beat Knechtle, et al., *Trends in Triathlon Performance: Effects of Sex & Age*, 43 SPORTS MED 851 (2013):

36. Based on data from a variety of elite triathlon and ultra-triathlon events spanning 22 years, the Lepers et al. (2013) authors reported that "elite males appear to run approximately 10–12 % faster than elite females across all endurance running race distances up to marathon, with the sex difference narrowing as the race distance increases. However, at distances greater than 100 km, such as the 161-km ultramarathon, the difference seems even larger, with females 20–30 % slower than males." (853)

/ / /

/ / /

/ / /

/ / /

/ / /

[1] Throughout this declaration, in the interest of readability I have omitted internal citations from my quotations from the articles I cite. The sources cited by these authors may of course be found by reference to those articles.

37. Lepers and Knechtle Table 1 below shows the "[m]ean sex differences in time performance for swimming, cycling, running and total time at different national and international triathlons." (854)

Event	Sex difference in time performance (%)			
	Swim	Cycle	Run	Total
Short distance (1.5–40–10 km): [30, 79]				
Zurich (Switzerland) from 2000 to 2010				
Top five elite overall	15.2	13.4	17.1	14.8
Top five AG, from 18 to 54 years	18.5	15.5	18.5	17.1
World Championship from 2009 to 2011				
Top ten AG, from 18 to 64 years	13.3	10.7	7.5	12.0
Half Ironman (1.9–90–21 km): [31, 79]				
Rapperswil (Switzerland) from 2007 to 2010				
Top five elite overall	14.1	12.3	12.5	12.6
Top five AG, from 18 to 54 years	22.3	16.4	19.2	17.6
World Championship from 2009 to 2011				
Top ten AG, from 18 to 64 years	12.4	11.2	14.5	12.6
Off-road triathlon (1.5–30–10 km): [9]				
World championship (Maui, USA) from 2007 to 2009				
Top ten elite overall	12.4	19.6	18.4	18.2
Ironman (3.8–180–42 km): [2, 32, 34]				
World championship (Kona, Hawaii, USA) from 1988 to 2007				
Top ten elite overall	9.8	12.7	13.3	12.6
Top ten AG, from 18 to 64 years	12.1	15.4	18.2	15.8
Zurich (Switzerland) from 1995 to 2010				
Top ten elite overall	14.0	13.2	18.2	14.9

38. "[F]or ultratriathlons, it has been shown that with increasing length of the event, the best females became relatively slower compared with the best males. Indeed, if the world's best performances are considered, males were 19 % faster than the females in both Double and Triple Ironman distance, and 30 % faster in the Deca-Ironman distance." (854)

39. "The average sex difference in swimming performance during triathlon for race distances between 1.5 and 3.8 km ranged between approximately 10 and 15 % for elite triathletes." (854)

40. Lepers and Knechtle Table 2 below shows the "[m]ean percentage differences in times for swimming, cycling, running and total event between the top ten females and males … in 2012 at four international triathlons:" (855)

Event	Sex difference in performance in top ten athletes in 2012 (mean ± SD)			
	Swim	Cycle	Run	Total
Hawaii Ironman Triathlon (3.8–180–42 km)	14.1 ± 7.9	13.1 ± 2.3	7.3 ± 2.9	11.3 ± 0.5
Olympics Triathlon (1.5–40–10 km) with drafting	11.8 ± 2.0	11.3 ± 0.6	14.7 ± 0.8	14.1 ± 7.9
Hy-Vee Triathlon (1.5–40–10 km) without drafting	8.6 ± 4.8	10.2 ± 3.5	8.6 ± 4.4	9.3 ± 0.5
World Championship Off-Road Triathlon (1.5–30–10 km)	15.2 ± 15.5	22.6 ± 4.4	15.1 ± 6.7	17.3 ± 2.9

41. "[T]he sex difference in performance between the best male and female ultraswimmers is more generally close to 11–12 %, which corresponds to values observed for swimming in triathlon." (855)

42. "Sex differences in triathlon cycling vary from 12 to 16% according to the level of expertise of participating triathletes for road-based triathlons." (855)

43. "In track cycling, where females are generally weaker than males in terms of power/weight ratios, the performance gap between males and females appears to be constant (<11 %) and independent of the race distance from 200 to 1,000 m." (855)

44. "In ultra-cycling events, such as the 'Race Across America,' sex difference in performance was around 15 % among top competitors. Greater muscle mass and aerobic capacity in males, even expressed relative to the lean body mass, may represent an advantage during long-distance cycling, especially on a relatively flat course such as Ironman cycling, where cycling approximates to a non-weight-bearing sport. Indeed, it has been shown that absolute power output (which is greater for males than for females) is associated with successful cycling

endurance performance because the primary force inhibiting forward motion on a flat course is air resistance." (855-56)

45. "Interestingly, for elite triathletes, the sex difference in mountain bike cycling during off-road triathlon (<20 %) is greater than cycling sex differences in conventional road-based events. Mountain biking differs in many ways from road cycling. Factors other than aerobic power and capacity, such as off-road cycling economy, anaerobic power and capacity, and technical ability might influence off-road cycling performance. Bouts of high-intensity exercise frequently encountered during the mountain biking leg of off-road triathlon (lasting <1 h 30 min for elite males and <2 h for elite females) can result from (1) having to overcome the constraints of gravity associated with steep climbs, (2) variable terrain necessitating wider tires and thus greater rolling resistance, and (3) isometric muscle contractions associated with the needs of more skilled bike-handling skills, not so often encountered in road cycling. However, in particular, lower power-to-weight ratios for female than for male triathletes inevitably leave them at a disadvantage during steep climbs." (856)

46. "During the 1988–2007 period, the top ten elite males have run the Hawaii Ironman marathon on average 13.3 % faster than the top ten females." (856)

E. Espen Tønnessen, Ida Siobhan Svendsen, et al., *Performance Development in Adolescent Track & Field Athletes According to Age, Sex & Sport Discipline,* 10:6 PLoS ONE 1 (2015):

47. While both sexes increase performance across the teen years, the Tønnessen et al. (2015) authors found performance advantages for male athletes associated with the onset of puberty and becoming increasingly larger across the years of puberty, in a chronological progression that was closely similar across diverse track and field events.

48. "The current results indicate that the sex difference evolves from < 5% to 10–18% in all the analyzed disciplines from age 11 to 18 yr. The gap widens considerably during early adolescence before gradually stabilizing when approaching the age of 18. This evolution is practically identical for the running and jumping disciplines. The observed sex differences at the age of 18 are in line with previous studies of world-class athletes where a sex difference of 10–12% for running events and ~19% for jumping events has been reported." (8)

49. "Male and female athletes perform almost equally in running and jumping events up to the age of 12. Beyond this age, males outperform females. Relative annual performance development in females gradually decreases throughout the analyzed age period. In males, annual relative performance development accelerates up to the age of 13 (for running events) or 14 (for jumping events) and then gradually declines when approaching 18 years of age. The relative improvement from age 11 to 18 was twice as high in jumping events compared to running events. For all of the analyzed disciplines, overall improvement rates were >50% higher for males than for females. The performance sex difference evolves from < 5% to 10-18% in all the analyzed disciplines from age 11 to 18 yr." (1)

50. "Recent studies of world-class athletes indicate that the sex difference is 10–12% for running events and ~19% for jumping events." (2)

/ / /

/ / /

/ / /

/ / /

/ / /

/ / /

51. Tønnessen and Svendsen's Table 1 below shows the "[e]xpected progressions in running and jumping performance for 11-18 [year] old males and females," as deduced from "[t]he 100 all-time best Norwegian male and female 60-m, 800-m, long jump and high jump athletes in each age category . . . ." (1, 4)

Table 1. Expected progressions in running and jumping performance for 11–18 yr old males and females.

Age *(yr)*	60 m		800 m		Long Jump		High Jump	
	Boys *Progression (s and %)*	Girls *Progression (s and %)*	Boys *Progression (s and %)*	Girls *Progression (s and %)*	Boys *Progression m (%)*	Girls *Progression m (%)*	Boys *Progression m (%)*	Girls *Progression m (%)*
11–12	-0.35 (4.1)	-0.35 (4.0)	-6.4 (4.4)	-7.3 (4.8)	+0.35 (7.4)	+0.36 (7.9)	+0.11 (7.4)	+0.10 (7.2)
12–13	-0.48 (5.8)	-0.25 (2.9)	-8.7 (6.2)	-5.5 (3.8)	+0.43 (8.6)	+0.30 (6.0)	+0.12 (7.9)	+0.09 (6.3)
13–14	-0.29 (3.7)	-0.16 (2.0)	-5.9 (4.5)	-3.6 (2.6)	+0.50 (9.0)	+0.21 (4.1)	+0.13 (8.1)	+0.06 (3.6)
14–15	-0.10 (1.3)	-0.02 (0.2)	-5.2 (4.1)	-2.2 (1.6)	+0.34 (5.6)	+0.13 (2.4)	+0.08 (4.3)	+0.04 (2.4)
15–16	-0.17 (2.3)	-0.08 (1.0)	-3.2 (2.7)	-1.6 (1.2)	+0.28 (4.4)	+0.10 (1.8)	+0.07 (3.6)	+0.03 (1.8)
16–17	-0.10 (1.4)	-0.07 (0.8)	-2.3 (1.9)	-1.5 (1.2)	+0.19 (2.9)	+0.06 (1.1)	+0.05 (2.5)	+0.01 (0.6)
17–18	-0.05 (0.7)	-0.02 (0.2)	-1.5 (1.4)	-0.6 (0.4)	+0.17 (2.5)	+0.02 (0.4)	+0.04 (1.9)	+0.01 (0.5)

Data are mean (standard deviation) for top 100 Norwegian male and female performers in each discipline.

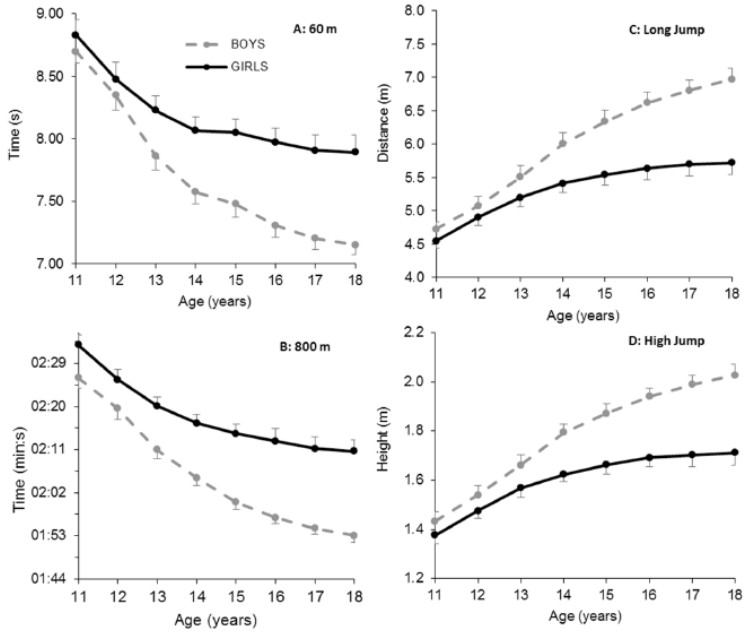
52. Tønnessen and Svendsen's Table 2 below shows the "[s]ex ratio in running and jumping performance for 11-18 [year] old males and females," as deduced from "[t]he 100 all-time best Norwegian male and female 60-m, 800-m, long jump and high jump athletes in each age category . . . ." (1, 6)

Table 2. Sex ratio in running and jumping performance for 11–18 yr old males and females.

	60 m	*800 m*	*Long Jump*	*High Jump*
11	0.99	0.95	0.96	0.97
12	0.98	0.96	0.97	0.96
13	0.96	0.93	0.94	0.95
14	0.94	0.92	0.90	0.90
15	0.93	0.89	0.87	0.89
16	0.92	0.88	0.85	0.87
17	0.91	0.87	0.84	0.85
18	0.91	0.86	0.82	0.84

Data are calculated from mean results of top 100 Norwegian male and female performers in each discipline.

53. Tønnessen and Svendsen's Figure 1 below shows "[p]erformance development from age 11 to 18 in running and jumping disciplines. Data are mean ± [standard deviation] for 60 m, 600 m, long jump, and high jump for top 100 Norwegian male and female performers in



each discipline:" (4)

/ / /

/ / /

/ / /

/ / /

/ / /

/ / /

/ / /

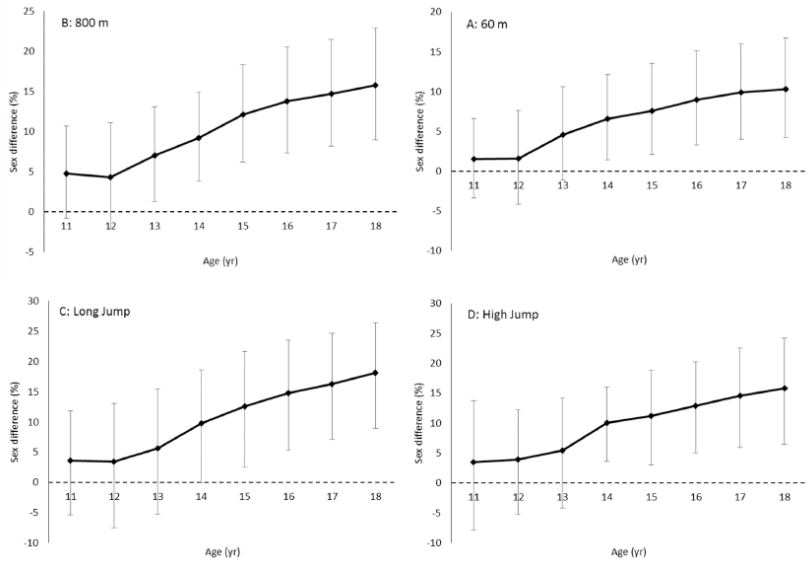
/ / /

/ / /

/ / /

/ / /

54. Tønnessen and Svendsen's Figure 3 below shows the "[s]ex difference for performance in running and jumping disciplines from age 11 to 18. Data are mean and 95% [confidence intervals] for 60 m, 600 m, long jump, and high jump for top 100 Norwegian male and female performers in each discipline:" (6)



55. As for the 60m race, the tables and charts above illustrate:

a. "[B]oys improve 0.3–0.5 [seconds] over 60 m sprint each year up to the age of 14 [years] (very large to nearly perfect annual effect), 0.1–0.2 [seconds] annually from 14 to 17 [years] (moderate to large annual effect), and 0.05 [seconds] from age 17 to 18 [years] (moderate effect). Relative annual improvement peaks between 12 and 13 [years] (5.8%; nearly perfect effect), and then gradually declines to 0.7% between age 17 and 18 [years] (moderate effect)." (3)

b. "On average, boys improve their 60 m performance by 18% from age 11 to 18 [years]. Girls improve 0.35 [seconds] over 60 m from age 11 to 12 [years] (4%; very large effect). Then, absolute and relative annual improvement gradually slows and almost plateaus between age 14 and 15 (0.02 s; 0.2%; trivial effect). From age 15 to 17,

annual improvement increases somewhat to 0.07–0.08 [seconds] (~1%; moderate effect) before plateauing again between age 17 and 18 (0.02 s; 0.2%; trivial effect). In total, girls improve their 60-m performance by 11% from age 11 to 18 [years]…. [T]he sex difference for 60 m sprint evolves from 1.5% at age 11 to 10.3% at the age of 18…. [T]he sex ratio for 60 m running performance develops from 0.99 at age 11 to 0.91 at age 18." (4-5)

56. As for the 800m race, the tables and charts above illustrate:

a. "[B]oys improve 6–9 [seconds] over 800 m each year up to age 14 [years] (very large to nearly perfect annual effect). Relative annual improvement peaks between age 12 and 13 (6.2%; nearly perfect effect), then gradually decreases to 1.5 [seconds] between age 17 and 18 (1.4%; moderate effect)." (5)

b. "On average, boys enhance their 800-m performance by 23% from age 11 to 18. For girls, both absolute and relative annual performance development gradually decreases across the analysed age stages. The improvement is slightly above 7 [seconds] between age 11 and 12 [years] (4.8%: very large effect), decreasing to only 0.6 [seconds] from age 17 to 18 (0.4%; small effect)…. [G]irls enhance their 800-m performance by 15% from age 11 to 18. The 800 m performance sex difference evolves from 4.8% at the age of 11 to 15.7% at the age of 18…. [T]he sex ratio for 800 m running performance develops from 0.95 at age 11 to 0.86 at age 18." (5)

57. As for the long jump, the tables and charts above illustrate:

a. "[A]nnual long jump improvement among boys gradually increases from 35 cm between age 11 and 12 [years] (7.4%; very large effect) to 50 cm between age 13

and 14 (9%; very large effect). Both absolute and relative annual development then gradually falls to 17 cm between age 17 and 18 (2.5%; moderate effect)." (5)

b. "[B]oys, on average, improve their long jump performance by 48% from age 11 to 18 yr. For girls, both absolute and relative annual performance enhancement gradually falls from age 11 to 12 [years] (36 cm; 7.9%; very large effect) until nearly plateauing between 17 and 18 [years] (2 cm; 0.4%; trivial effect). Overall, girls typically improve their long jump performance by 26% throughout the analysed age stages. The sex difference in long jump evolves from 3.6% at the age of 11 to 18% at the age of 18…. [T]he sex ratio for long jump performance develops from 0.96 at age 11 to 0.82 at age 18." (5)

58. As for the high jump, the tables and charts above illustrate:

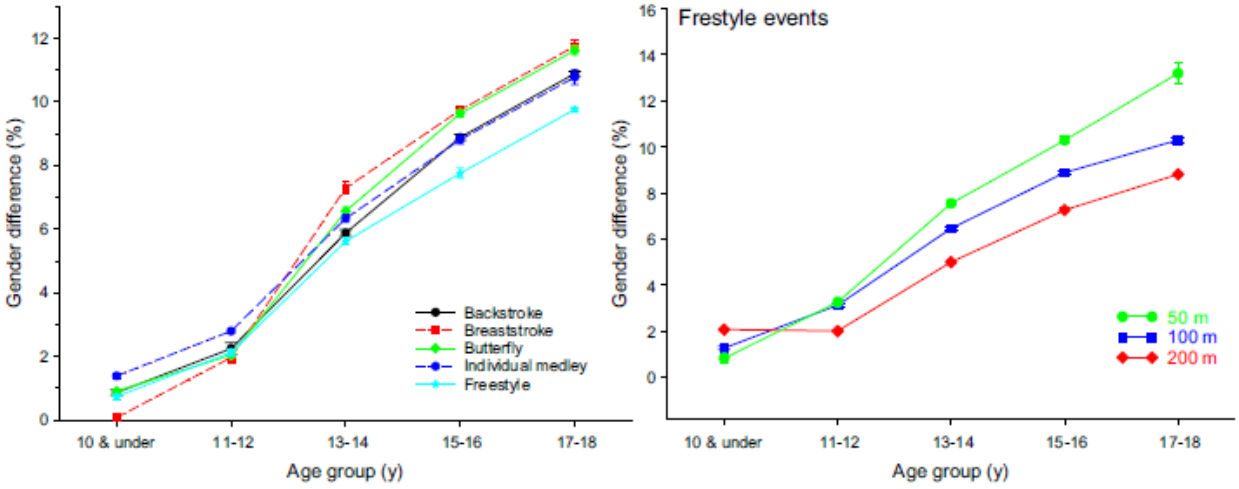
a. "[B]oys improve their high jump performance by 11–13 cm each year up to the age of 14 (7–8%; very large annual effects). Both absolute and relative annual improvement peaks between age 13 and 14 (13 cm; 8.1%; very large effect), then gradually decreases to 4 cm from age 17 to 18 (1.9%; moderate annual effect)." (6)

b. "Overall, boys improve their high jump performance by, on average, 41% from age 11 to 18. For girls, both absolute and relative annual improvement decreases from 10 cm from age 11 to 12 [years] (7.2%; very large effect) until it plateaus from age 16 (1 cm; ~0.5%; small annual effects). Overall, girls typically improve their high jump performance by 24% from age 11 to 18. The sex difference in high jump performance evolves from 3.5% at the age of 11 to 16% at the age of 18…. [T]he sex ratio for high jump performance develops from 0.97 at age 11 to 0.84 at age 18." (6-7)

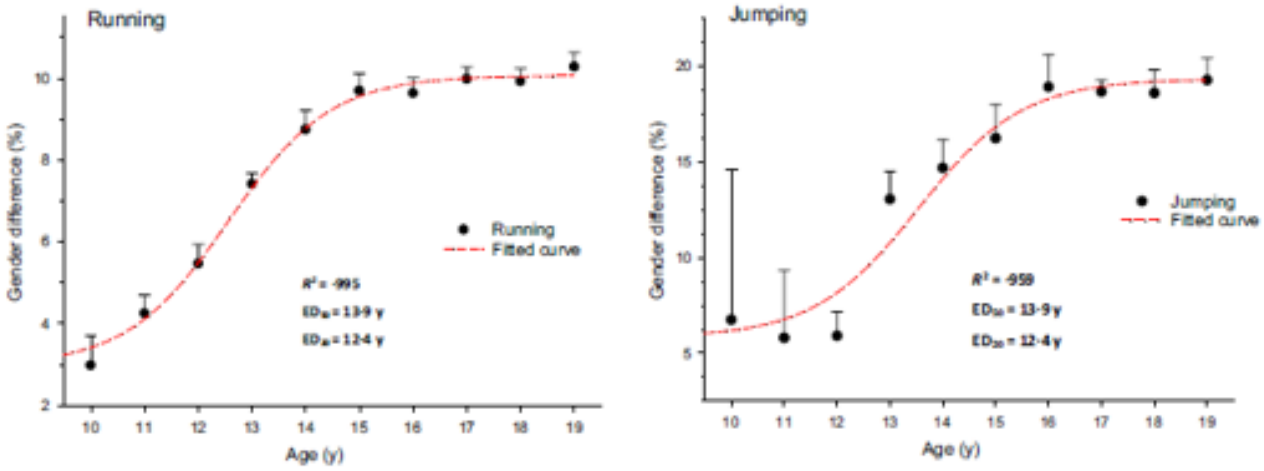
F. David J. Handelsman, *Sex Differences in Athletic Performance Emerge Coinciding with the Onset of Male Puberty*, 87 CLINICAL ENDOCRINOLOGY 68 (2017):

59. Analyzing four separate studies, Handelsman (2017) found very closely similar trajectories of divergence of athletic performance between the sexes across the adolescent years, in all measured events.

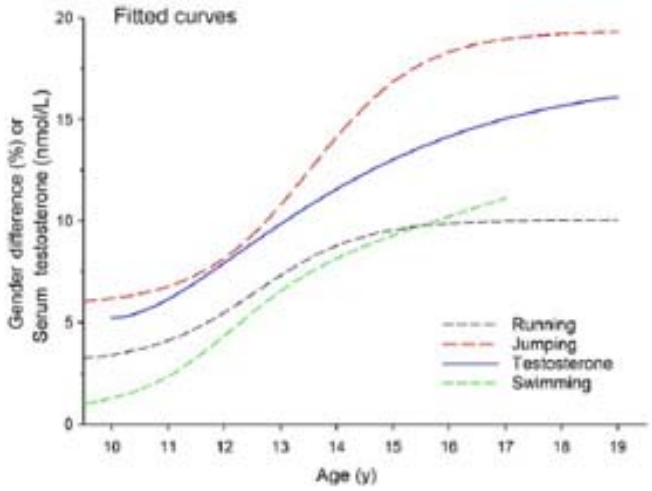
60. As illustrated by Figure 1 of Handelsman (2017) below, study results showed that "[i]n swimming performance, the overall gender differences were highly significant . . . ." (69)



61. As illustrated by Figure 2 of Handelsman (2017) below, "[i]n track and field athletics, the effects of age on running performance showed that the prepubertal differences of 3.0% increased to a plateau of 10.1% with an onset (ED_{20}) at 12.4 years and reaching midway (ED_{50}) at 13.9 years. For jumping, the prepubertal difference of 5.8% increased to 19.4% starting at 12.4 years and reaching midway at 13.9 years." (70)



62. As also illustrated in Figure 2 of Handelsman (2017), the author found a strong correlation between the increasing male performance advantage and blood serum testosterone levels, and reported: "The timing of the male advantage in running, jumping and swimming was similar [across events] and corresponded to the increases in serum testosterone in males." (70)



G. Moran Gershoni & Shmuel Pietrokovski, *The landscape of sex-differential transcriptome and its consequent selection in human adults*, 15 BMC BIOL 7 (2017):

63. The authors of this article evaluated "18,670 out of 19,644 informative protein-coding genes in men versus women" (2) and reported that "there are over 6500 protein-coding

genes with significant S[ex-]D[ifferential]E[xpression] in at least one tissue. Most of these genes have SDE in just one tissue, but about 650 have SDE in two or more tissues, 31 have SDE in more than five tissues, and 22 have SDE in nine or more tissues." (2) Some examples of tissues identified by these authors that have SDE genes include breast mammary tissue, skeletal muscle, skin, thyroid gland, pituitary gland, subcutaneous adipose, lung, and heart left ventricle. Based on these observations the authors state "As expected, Y-linked genes that are normally carried only by men show SDE in many tissues." (3) This evaluation of SDE in protein coding genes helps illustrate that the differences between men and women are intrinsically part of the chromosomal and genetic makeup of humans which can influence many tissues that are inherent to the athletic competitive advantages of men compared to women.

H. K. M. Haizlip, et al., Sex-based differences in skeletal muscle kinetics and fiber-type composition, 30 PHYSIOLOGY (BETHESDA) 30 (2015):

64. In a review of 56 articles on the topic of sex-based differences in skeletal muscle, the authors state that "More than 3,000 genes have been identified as being differentially expressed between male and female skeletal muscle []." (30) Furthermore, the authors state that "Overall, evidence to date suggests that skeletal muscle fiber-type composition is dependent on species, anatomical location/function, and sex." (30) The differences in genetic expression between males and females influence the skeletal muscle fiber composition (i.e. fast twitch and fast twitch sub-type and slow twitch), the skeletal muscle fiber size, the muscle contractile rate, and other aspects of muscle function that influence athletic performance. As the authors review the differences in skeletal muscle between males and females they conclude "Additionally, all of the fibers measured in men have significantly larger cross-sectional areas (CSA) compared with women []." (31) The authors also explore the effects of thyroid hormone, estrogen, and

testosterone on gene expression and skeletal muscle function in males and females. One major conclusion by the authors is that "The complexity of skeletal muscle and the role of sex adding to that complexity cannot be overlooked." (37).

I. Konstantinos D. Tambalis, et al., Physical fitness normative values for 6-18-year-old Greek boys and girls, using the empirical distribution and the lambda, mu, and sigma statistical method, 16 EUR J SPORT SCI 736 (2016). Mark J. Catley & G. R. Tomkinson, Normative health-related fitness values for children: analysis of 85347 test results on 9-17-year-old Australians since 1985, 47 BR J SPORTS MED 98 (2013). Grant R. Tomkinson, et al., *European normative values for physical fitness in children and adolescents aged 9-17 years: results from 2 779 165 Eurofit performances representing 30 countries*. 52 Br J Sports Med. 1445 (2018):

65. The purpose in citing these sources is to illustrate that males possess physical fitness traits that likely provide an advantage in athletic performance, that these male advantages may be apparent in children starting as young as six years of age, and in agreement with previously cited sources the differences become more apparent at the onset of puberty.

66. Tambalis et al. (2016) states that "based on a large data set comprising 424,328 test performances" (736) using standing long jump to measure lower body explosive power, sit and reach to measure flexibility, timed 30 second sit ups to measure abdominal and hip flexor muscle endurance, 10 X 5 meter shuttle run to evaluate speed and agility, and multi-stage 20 meter shuttle run test to estimate aerobic performance (738) "For each of the fitness tests, performance was better in boys compared with girls ($p < 0.001$), except for the S[it and] R[each] test ($p < 0.001$)." (739) In order to illustrate that the findings of Tambalis (2016) are not unique to children in Greece, the authors state "Our findings are in accordance with recent studies from Latvia [ ] Portugal [ ] and Australia [Catley & Tomkinson (2013)].(744)

67. Catley & Tomkinson (2013) observed that "Boys consistently scored higher than girls on health-related fitness tests, except on the sit-and-reach test, with the magnitude of the

differences typically increasing with age and often accelerating from about 12 years of age. Overall, the magnitude of differences between boys and girls was large for the 1.6 km run, 20 m shuttle run, basketball throw and push-ups; moderate for the 50-m sprint, standing broad jump and sit-and-reach; and small for sit-ups and hand-grip strength." (106)

68. Evaluating performance on the "Eurofit tests (measuring balance, muscular strength, muscular endurance, muscular power, flexibility, speed, speed-agility and cardiorespiratory fitness)" in "2,779,165 results on children and adolescents [ages 9-17 years] from 30 European countries" Tomkinson et al. (2018) observed that "On average, boys performed substantially better than girls at each age group on muscular strength (E[ffect]S[ize]: large), muscular power (E[ffect]S[ize]: large), muscular endurance (E[ffect]S[ize]: moderate to large), speed-agility (E[ffect]S[ize]: moderate) and C[ardio]R[espiratory]F[itness] (E[ffect]S[ize]: large) tests, with the magnitude of the sex-specific differences increasing with age and accelerating from about 12 years"" (1451). Given the number of subjects analyzed and that the data represent 30 different European countries, these findings particularly highlight the sex related differences in athletic performance potential between boys and girls both before and during adolescence.

J. Daniel M. Fessler, et al., *Sexual dimorphism in foot length proportionate to stature,* 32 ANN HUM BIOL 44 (2005). Roshna E. Wunderlich & P. R. Cavanagh, *Gender differences in adult foot shape: implications for shoe design,* 33 MED SCI SPORTS EXERC (2001):

69. Combined, these two articles evaluate and demonstrate clear differences in the foot length and structure of men and women. Of relevance to the case at hand is that to the best of my knowledge, no data are available demonstrating that male-to-female transgender hormone or surgical treatment alters the inherent sex related difference in foot structure.

70. Fessler et al. (2005) observes that "female foot length is consistently smaller than male foot length" (44) and conclude that "proportionate foot length is smaller in women"(51) with an overall conclusion that "Our analyses of genetically disparate populations reveal a clear pattern of sexual dimorphism, with women consistently having smaller feet proportionate to stature than men." (53)

71. Wunderlich & Cavanaugh (2001) observe that "a foot length of 257 mm represents a value that is … approximately the 20th percentile men's foot lengths and the 80th percentile women's foot lengths." (607) and "For a man and a woman, both with statures of 170 cm (5 feet 7 inches), the man would have a foot that was approximately 5 mm longer and 2 mm wider than the woman" (608). Based on these, and other analyses, they conclude that "female feet and legs are not simply scaled-down versions of male feet but rather differ in a number of shape characteristics, particularly at the arch, the lateral side of the foot, the first toe, and the ball of the foot." (605)

K. Daichi. Tomita, et al., *A pilot study on the importance of forefoot bone length in male 400-m sprinters: is there a key morphological factor for superior long sprint performance*?, 11 BMC RES NOTES 583 (2018). Hiromasa Ueno, et al., *The Potential Relationship Between Leg Bone Length and Running Performance in Well-Trained Endurance Runners*, 70 J HUM KINET 165 (2019). Hiromasa Ueno, et al., *Association between Forefoot Bone Length and Performance in Male Endurance Runners*, 39 INT J SPORTS MED 275 (2018):

72. As men have longer feet and legs than women as part of their overall larger body stature, collectively these articles build upon the work of Fessler et al. (2005) and Wunderlich & Cavanaugh (2001) by providing some evidence that "morphological factors such as long forefoot bones may play an important role in achieving superior long sprinting performance" (Tomito, 583), "longer forefoot bones may be advantageous for achieving higher running performance in

endurance runners" (Ueno 2018, 275)" and "the leg bone length, especially of the tibia, may be a potential morphological factor for achieving superior running performance in well-trained endurance runners." (Ueno 2019, 165)

L. International Weightlifting Federation "World Records"

73. I accessed weightlifting records as posted by the International Weightlifting Federation at https://www.iwf.net/results/world-records/. The records collected below are as of November 1, 2019.

74. As the chart below illustrates, junior men's and women's world records (age 15-20) for clean and jerk lifts indicate that boys or men perform better than girls or women even when they are matched for body mass. Similar sex differences can be found for the snatch event on the International Weightlifting Federation website.

Junior Men's and Women's World Records (ages 15-20) for Clean and Jerk			
Men's weight (kg)	Record (kg)	Women's weight (kg)	Record (kg)
56	171	58	142
62	183	63	147
69	198	69	157
77	214	75	164
85	220	90	160
94	233	+90	193

M. Selected Results from the 2019 NCAA Division 1 and Division 2 Track & Field Championships

75. I accessed the results for the NCAA 2019 Division 1 Track and Field Championships at https://www.flotrack.org/results/6515701-2019-D1-ncaa-outdoor-championships/26635 on May 14, 2020. I also accessed the results for the NCAA Divisions 2 Track and Field Championships at http://leonetiming.com/2019/Outdoor/NCAAD2/Results.htm on May 14, 2020.

76. A shown in the table below, in this small sampling of Track & Field events at the elite collegiate level of Division 1, the men's eighth place finisher and often all 24 men's qualifiers, outperformed the first place women's athlete in the same event. Furthermore, at the Division 2 level, which is arguably a less elite level of performance than Division 1, in most (if not all) events, the top eight men's finishers outperformed the first place division 1 woman in the same event.

Comparison of selected performance in Men's and Women's events in the 2019 NCAA Division 1 and Division 2 Track and Field Championships.		
100 meter run (seconds)		
D1 Women	D1 Men	D2 Men
10.75	9.86	10.17
10.95	9.93	10.22
10.98	9.97	10.32
11.00	10.01	10.38
11.02	10.06	10.47
11.04	10.06	10.48
11.12	10.12	10.53
11.65	10.12	FS
D1 Men's slowest time in 100 m prelims: 10.67 (23rd place; 24th place DNS)		
D1 Women's fastest time in 100 m prelims: 10.99		
1500 m run (minutes: seconds)		
D1 Women	D1 Men	D2 Men
4:05.98	3:41.39	3:58.24
4:06.27	3:41.39	3:58.74
4:11.96	3:42.14	3:58.90
4:13.02	3:42.29	3:59.02
4:13.57	3:42.32	3:59.47
4:13.62	3:42.73	3:59.55
4:14.30	3:42.77	3:59.65
4:14.73	3:42.81	3:59.93
D1 Men's slowest time in 1500 m prelims: 3:53.53 (24th place)		
D1 Women's fastest time in 1500 m prelims: 4:12.02		
10,000 m run (minutes: Seconds)		
D1 Women	D1 Men	D2 Men
33:10.84	29:16.60	30:12.3
33:11.56	29:18.10	30:59.78

33:17.81	29:19.85	31:05.87
33:20.68	29:19.93	31:07.37
33:20.70	29:20.73	31:11.07
33:25.91	29:25.35	31:13.39
33:32.80	29:26.34	31:14.69
33:34.20	29:30.88	31:18.75
D1 Men's slowest time in 10,000 m prelims: 31:20.16 (24th place)		
Long Jump (meters)		
D1 Women	D1 Men	DII Men
6.84	8.2	8.16
6.71	8.18	8.08
6.63	8.12	7.96
6.55	8.05	7.86
6.49	8.00	7.79
6.44	7.88	7.72
6.43	7.87	7.72
6.40	7.83	7.71
D1 Men's 21st place longest jump 7.38 m (22nd foul, 23rd & 24th DNS)		
Shot Put (meters) Note that men use 7.26 kg (16 lbs.) shot, women use 4 kg (8.82 lbs.) shot		
D1 Women	D1 Men	D II Men
18.14	21.11	21.47
18.11	20.77	19.58
17.88	20.31	18.71
17.67	19.89	18.62
17.46	19.73	18.43
17.24	19.65	18.34
17.13	19.65	18.30
16.94	19.52	18.03
D1 Men's 23rd place longest put 16.90 m (24th Foul)		

II. Biological male physiology is the basis for the performance advantage that men, or adolescent boys, have over women, or adolescent girls, in almost all athletic contests.

77. Common observation and knowledge tell us that, across the years of puberty, boys experience distinctive physical developments that largely explain the performance advantages I have detailed above. These well-known physical developments have now also been the subject of scientific measurement and study.

78. At the onset of male puberty the testes begin to secrete greatly increased amounts of testosterone. Testosterone is the primary “androgenic” hormone. It causes the physical traits associated with males such as facial and body hair growth, deepening of the voice, enlargement of the genitalia, increased bone mineral density, increased bone length in the long bones, and enhanced muscle growth (to name just a few of testosterone’s effects). The enhanced muscle growth caused by testosterone is the “anabolic” effect often discussed when testosterone is called an anabolic steroid.

79. Women lack testes and instead have ovaries, so they do not experience similar increases in testosterone secretion. Instead, puberty in women is associated with the onset of menstruation and increased secretion of “estrogens.” Estrogens, most notably estradiol, cause the feminizing effects associated with puberty in women which include increased fat tissue growth in the hips, thighs, and buttocks, development of the mammary glands, and closure of the growth plates in long bones. The smaller amount of muscle growth typically seen in women during puberty explains in part the athletic performance gap between men, and boys after the onset of puberty, and women and girls.

A. Handelsman, Hirschberg, et al. (2018):

80. In addition to documenting objective performance advantages enjoyed by males as I have reviewed above, Handelsman and his co-authors also detail physiological differences caused by male puberty—and by developments during puberty under the influence of male levels of testosterone in particular—that account for those advantages. These authors state: “The striking male postpubertal increase in circulating testosterone provides a major, ongoing, cumulative, and durable physical advantage in sporting contests by creating larger and stronger bones, greater muscle mass and strength, and higher circulating hemoglobin as well as possible

psychological (behavioral) differences. In concert, these render women, on average, unable to compete effectively against men in power-based or endurance-based sports." (805)

81. First, Handelsman et al. explain that all of these physiological differences appear to be driven by male levels of circulating testosterone. "The available, albeit incomplete, evidence makes it highly likely that the sex difference in circulating testosterone of adults explains most, if not all, of the sex differences in sporting performance. This is based on the dose-response effects of circulating testosterone to increase muscle mass and strength, bone size and strength (density), and circulating hemoglobin, each of which alone increases athletic capacity, as well as other possible sex dichotomous, androgen-sensitive contributors such as mental effects (mood, motivation, aggression) and muscle myoglobin content. These facts explain the clear sex difference in athletic performance in most sports, on which basis it is commonly accepted that competition has to be divided into male and female categories." (823)

82. "Prior to puberty, levels of circulating testosterone as determined by LC-MS are the same in boys and girls . . . . They remain lower than 2 nmol/L in women of all ages. However, from the onset of male puberty the testes secrete 20 times more testosterone resulting in circulating testosterone levels that are 15 times greater in healthy young men than in age-similar women." (806) "[T]he circulating testosterone of most women never reaches consistently >5 nmol/L, a level that boys must sustain for some time to exhibit the masculinizing effects of male puberty." (808)

83. "The characteristic clinical features of masculinization (e.g., muscle growth, increased height, increased hemoglobin, body hair distribution, voice change) appear only if and when circulating testosterone concentrations rise into the range of males at mid-puberty, which

are higher than in women at any age even after the rise in circulating testosterone in female puberty." (810)

84. "[The] order-of-magnitude difference in circulating testosterone concentrations is the key factor in the sex difference in athletic performance due to androgen effects principally on muscle, bone, and hemoglobin." (811)

85. "Modern knowledge of the molecular and cellular basis for androgen effects on skeletal muscle involves effects due to androgen (testosterone, DHT) binding to the AR that then releases chaperone proteins, dimerizes, and translocates into the nucleus to bind to androgen response elements in the promoter DNA of androgen-sensitive genes. This leads to increases in (1) muscle fiber numbers and size, (2) muscle satellite cell numbers, (3) numbers of myonuclei, and (4) size of motor neurons. Additionally, there is experimental evidence that testosterone increases skeletal muscle myostatin expression, mitochondrial biogenesis, myoglobin expression, and IGF-1 content, which may augment energetic and power generation of skeletal muscular activity." (811)

86. **Muscle mass** is perhaps the most obvious driver of male athletic advantage. "On average, women have 50% to 60% of men's upper arm muscle cross-sectional area and 65% to 70% of men's thigh muscle cross-sectional area, and women have 50% to 60% of men's upper limb strength and 60% to 80% of men's leg strength. Young men have on average a skeletal muscle mass of >12 kg greater than age-matched women at any given body weight. Whereas numerous genes and environmental factors (including genetics, physical activity, and diet) may contribute to muscle mass, the major cause of the sex difference in muscle mass and strength is the sex difference in circulating testosterone." (812)

87. "Dose-response studies show that in men whose endogenous testosterone is fully suppressed, add-back administration of increasing doses of testosterone that produce graded increases in circulating testosterone causes a dose-dependent (whether expressed according to testosterone dose or circulating levels) increase in muscle mass (measured as lean body mass) and strength. Taken together, these studies prove that testosterone doses leading to circulating concentrations from well below to well above the normal male range have unequivocal dose-dependent effects on muscle mass and strength. These data strongly and consistently suggest that the sex difference in lean body mass (muscle) is largely, if not exclusively, due to the differences in circulating testosterone between men and women. These findings have strong implications for power dependent sport performance and largely explain the potent efficacy of androgen doping in sports." (813)

88. "Muscle growth, as well as the increase in strength and power it brings, has an obvious performance enhancing effect, in particular in sports that depend on strength and (explosive) power, such as track and field events. There is convincing evidence that the sex differences in muscle mass and strength are sufficient to account for the increased strength and aerobic performance of men compared with women and is in keeping with the differences in world records between the sexes." (816)

89. Men and adolescent boys also have distinct athletic advantages in **bone size, strength, and configuration**.

90. "Sex differences in height have been the most thoroughly investigated measure of bone size, as adult height is a stable, easily quantified measure in large population samples. Extensive twin studies show that adult height is highly heritable with predominantly additive genetic effects that diverge in a sex-specific manner from the age of puberty onwards, the effects

of which are likely to be due to sex differences in adult circulating testosterone concentrations." "Men have distinctively greater bone size, strength, and density than do women of the same age. As with muscle, sex differences in bone are absent prior to puberty but then accrue progressively from the onset of male puberty due to the sex difference in exposure to adult male circulating testosterone concentrations." (818)

91. "The earlier onset of puberty and the related growth spurt in girls as well as earlier estrogen-dependent epiphyseal fusion explains shorter stature of girls than boys. As a result, on average men are 7% to 8% taller with longer, denser, and stronger bones, whereas women have shorter humerus and femur cross-sectional areas being 65% to 75% and 85%, respectively, those of men. These changes create an advantage of greater bone strength and stronger fulcrum power from longer bones." (818)

92. **Male bone geometry** also provides mechanical advantages. "The major effects of men's larger and stronger bones would be manifest via their taller stature as well as the larger fulcrum with greater leverage for muscular limb power exerted in jumping, throwing, or other explosive power activities." (818) Further, "the widening of the female pelvis during puberty, balancing the evolutionary demands of obstetrics and locomotion, retards the improvement in female physical performance, possibly driven by ovarian hormones rather than the absence of testosterone." (818)

93. Beyond simple performance, the greater density and strength of male bones provides higher protection against stresses associated with extreme physical effort: "[S]tress fractures in athletes, mostly involving the legs, are more frequent in females with the male protection attributable to their larger and thicker bones." (818)

94. In addition to advantages in muscle mass and strength, and bone size and strength, men and adolescent boys have **greater hemoglobin levels** in their blood as compared to women and girls, and thus a greater capability to transport oxygen within the blood, which then provides bioenergetic benefits. "It is well known that levels of circulating hemoglobin are androgen-dependent and consequently higher in men than in women by 12% on average…. Increasing the amount of hemoglobin in the blood has the biological effect of increasing oxygen transport from lungs to tissues, where the increased availability of oxygen enhances aerobic energy expenditure." (816) "It may be estimated that as a result the average maximal oxygen transfer will be ~10% greater in men than in women, which has a direct impact on their respective athletic capacities." (816)

B. Louis Gooren, *The Significance of Testosterone for Fair Participation of the Female Sex in Competitive Sports,* 13 Asian J. of Andrology 653 (2011):

95. Gooren et al. like Handelsman et al., link male advantages in height, bone size, muscle mass, strength, and oxygen carrying capacity to exposure to male testosterone levels: "Before puberty, boys and girls hardly differ in height, muscle and bone mass. Pubertal testosterone exposure leads to an ultimate average greater height in men of 12–15 centimeters, larger bones, greater muscle mass, increased strength and higher hemoglobin levels." (653)

C. Thibault, Guillaume, et al. (2010):

96. In addition to the testosterone-linked advantages examined by Handelsman et al. (2018), Thibault et al. note sex-linked differences in body fat as impacting athletic performance: "Sex has been identified as a major determinant of athletic performance through the impact of height, weight, body fat, muscle mass, aerobic capacity or anaerobic threshold as a result of genetic and hormonal differences []." (214)

D. Taryn Knox, Lynley C. Anderson, et al., *Transwomen in Elite Sport: Scientific & Ethical Considerations*, 45 J. MED ETHICS 395 (2019):

97. Knox et al. analyze specific testosterone-linked physiological differences between men and women that provide advantages in athletic capability, and conclude that "[E]lite male athletes have a performance advantage over their female counterparts due to physiological differences." (395) "Combining all of this information, testosterone has profound effects on key physiological parameters that underlie athletic performance in men. There is substantial evidence regarding the effects on muscle gain, bone strength, and the cardiovascular and respiratory system, all of which drive enhanced strength, speed and recovery. Together the scientific data point to testosterone providing an all-purpose benefit across a range of body systems that contribute to athletic performance for almost all sports." (397-98)

98. "It is well recognised that testosterone contributes to physiological factors including body composition, skeletal structure, and the cardiovascular and respiratory systems across the life span, with significant influence during the pubertal period. These physiological factors underpin strength, speed and recovery with all three elements required to be competitive in almost all sports. An exception is equestrian, and for this reason, elite equestrian competition is not gender-segregated. As testosterone underpins strength, speed and recovery, it follows that testosterone benefits athletic performance." (397)

99. "High testosterone levels and prior male physiology provide an all-purpose benefit, and a substantial advantage. As the IAAF says, 'To the best of our knowledge, there is no other genetic or biological trait encountered in female athletics that confers such a huge performance advantage.'" (399)

100. These authors, like others, describe sex-linked advantages relating to **bone size and muscle mass.** "Testosterone also has a strong influence on bone structure and strength. From puberty onwards, men have, on average, 10% more bone providing more surface area. The larger surface area of bone accommodates more skeletal muscle so, for example, men have broader shoulders allowing more muscle to build. This translates into 44% less upper body strength for women, providing men an advantage for sports like boxing, weightlifting and skiing. In similar fashion, muscle mass differences lead to decreased trunk and lower body strength by 64% and 72%, respectively in women. These differences in body strength can have a significant impact on athletic performance, and largely underwrite the significant differences in world record times and distances set by men and women." (397)

101. Knox et al. also identify the relatively higher percentage of **body fat** in women as both inherently sex-linked, and a disadvantage with respect to athletic performance. "Oestrogens also affect body composition by influencing fat deposition. Women, on average, have higher percentage body fat, and this holds true even for highly trained healthy athletes (men 5%–10%, women 8%–15%). Fat is needed in women for normal reproduction and fertility, but it is not performance enhancing. This means men with higher muscle mass and less body fat will normally be stronger kilogram for kilogram than women." (397)

102. Knox et al. detail the relative performance disadvantage arising from the oestrogen-linked **female pelvis shape**: "[T]he major female hormones, oestrogens, can have effects that disadvantage female athletic performance. For example, women have a wider pelvis changing the hip structure significantly between the sexes. Pelvis shape is established during puberty and is driven by oestrogen. The different angles resulting from the female pelvis leads to decreased joint rotation and muscle recruitment ultimately making them slower." (397)

103. "In short, higher testosterone levels lead to larger and stronger bones as well as more muscle mass providing a body composition-related performance advantage for men for almost all sports. In contrast, higher oestrogen levels lead to changes in skeletal structure and more fat mass that can disadvantage female athletes, in sports in which speed, strength and recovery are important." (397)

104. Knox et al. break out multiple sex-linked contributions to a male advantage in **oxygen intake and delivery**, and thus to energy delivery to muscles. "Testosterone also influences the cardiovascular and respiratory systems such that men have a more efficient system for delivering oxygen to active skeletal muscle. Three key components required for oxygen delivery include lungs, heart and blood haemoglobin levels. Inherent sex differences in the lung are apparent from early in life and throughout the life span with lung capacity larger in men because of a lower diaphragm placement due to Y-chromosome genetic determinants. The greater lung volume is complemented by testosterone-driven **enhanced alveolar multiplication rate** during the early years of life." (397)

105. "Oxygen exchange takes place between the air we breathe and the bloodstream at the alveoli, so more alveoli allows more oxygen to pass into the bloodstream. Therefore, the greater lung capacity allows more air to be inhaled with each breath. This is coupled with an improved uptake system allowing men to absorb more oxygen. Once in the blood, oxygen is carried by haemoglobin. Haemoglobin concentrations are directly modulated by testosterone so men have higher levels and can carry more oxygen than women. Oxygenated blood is pumped to the active skeletal muscle by the heart. The left ventricle chamber of the heart is the reservoir from which blood is pumped to the body. The larger the left ventricle, the more blood it can hold, and therefore, the more blood can be pumped to the body with each heartbeat, a

physiological parameter called ‘stroke volume’. The female heart size is, on average, 85% that of a male resulting in the stroke volume of women being around 33% less. Putting all of this together, men have a much more efficient cardiovascular and respiratory system, with testosterone being a major driver of enhanced aerobic capacity.” (397)

E. Lepers, Knechtle, et al. (2013):

106. Lepers et al. point to some of these same physiological differences as explaining the large performance advantage they found for men in triathlon performance. “Current explanations for sex differences in [maximal oxygen uptake] among elite athletes, when expressed relative to body mass, provide two major findings. First, elite females have more (<13 vs. <5 %) body fat than males. Indeed, much of the difference in [maximal oxygen uptake] between males and females disappears when it is expressed relative to lean body mass. Second, the hemoglobin concentration of elite athletes is 5–10 % lower in females than in males.” (853)

107. “Males possess on average 7–9 % less percent body fat than females, which is likely an advantage for males. Therefore, it appears that sex differences in percentage body fat, oxygen-carrying capacity and muscle mass may be major factors for sex differences in overall triathlon performance. Menstrual cycle, and possibly pregnancy, may also impact training and racing in female athletes, factors that do not affect males.” (853)

F. Tønnessen, Svendsen, et al. (2015):

108. Tønnessen et al. likewise point to some of the same puberty and testosterone-triggered physiological differences discussed above to explain the increasing performance advantage of boys across the adolescent years, noting that “[T]here appears to be a strong mechanistic connection between the observed sex-specific performance developments and hormone-dependent changes in body composition during puberty.” (7) “Beyond [age 12], males

outperform females because maturation results in a shift in body composition. Our results are in line with previous investigations exploring physical capacities such as [maximal oxygen uptake] and isometric strength in non-competitive or non-specialized adolescents." (7)

109. "[S]ex differences in physical capacities (assessed as [maximal oxygen uptake] or isometric strength in the majority of cases) are negligible prior to the onset of puberty. During the adolescent growth spurt, however, marked sex differences develop. This can primarily be explained by hormone dependent changes in body composition and increased red blood cell mass in boys." (2)

110. "Sexual dimorphism during puberty is highly relevant for understanding sex-specific performance developments in sports. The initiation of the growth spurt in well-nourished girls occurs at about 9–10 yrs of age. Age at peak height velocity (PHV) and peak weight velocity (PWV) in girls is 11–12 and 12–13 yrs, respectively, with an average 7–9 cm and 6–9 kg annual increase. The growth spurt and PHV in girls occurs approximately 2 years earlier than for boys. However, the magnitude of the growth spurt is typically greater in boys, as they on average gain 8–10 cm and 9–10 kg annually at PHV and PWV, respectively. Girls experience an escalation in fat mass compared to boys. Fat free mass (FFM) (also termed lean muscle mass) is nearly identical in males and females up to the age of 12–13 yrs. FFM plateaus in females at 15–16 years of age, but continues increasing in males up to the age of 19–20 yrs. On average, boys and girls increase their FFM by 7.2 and 3.5 kg/year^{-1}, respectively, during the interval near peak height velocity. Corresponding estimates for changes in absolute fat mass are 0.7 and 1.4 kg/year^{-1}, while estimates for relative fatness are -0.5% and +0.9%/year^{-1} in boys and girls, respectively." (2)

111. "During puberty, boys begin to produce higher levels of circulating testosterone. This affects the production of muscle fibers through direct stimulation of protein synthesis. Higher testosterone levels result in more muscle mass, which in turn facilitates greater power production and more advantageous ground reaction forces during running and jumping. Adolescent weight gain in boys is principally due to increased height (skeletal tissue) and muscle mass, while fat mass remains relatively stable. In contrast, during puberty girls begin to produce higher levels of circulating estrogen and other female sex hormones. Compared to their male counterparts, they experience a less pronounced growth spurt and a smaller increase in muscle mass, but a continuous increase in fat mass, thereby lowering the critical ratio between muscular power and total body mass." (7)

112. "The relatively greater progress in jumping exercises can also be explained by growth and increased body height during puberty. The increase in body height means that the center of gravity will be higher, providing better mechanical conditions for performance in jumping events." (8)

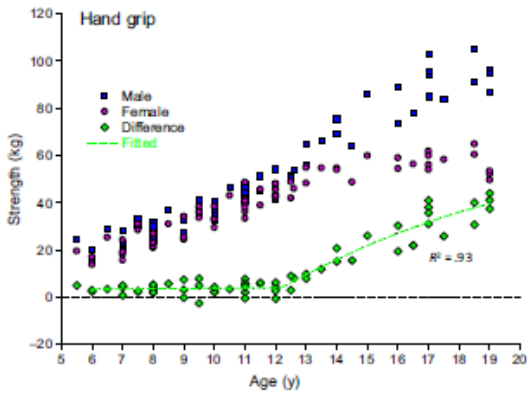
G. Louis J. G. Gooren & Mathijs C. M. Bunck, *Transsexuals & Competitive Sports,* 151 EUROPEAN J. OF ENDOCRINOLOGY 425 (2004):

113. In their study of performance of transsexual athletes, Louis et al. note that "[b]efore puberty, boys and girls do not differ in height, muscle and bone mass. Recent information shows convincingly that actual levels of circulating testosterone determine largely muscle mass and strength." (425) "Testosterone exposure during puberty leads ultimately to an average greater height in men of 12–15 cm, larger bones and muscle mass, and greater strength." (425)

H. Handelsman (2017):

114. Handelsman (2017) notes the existence of a "stable and robust" performance gap between males and females, with no narrowing "over more than three decades" (71), observing that "[i]t is well known that men's athletic performance exceeds that of women especially in power sports because of men's greater strength, speed and endurance. This biological physical advantage of mature males forms the basis for gender segregation in many competitive sports to allow females a realistic chance of winning events. This physical advantage in performance arises during early adolescence when male puberty commences after which men acquire larger muscle mass and greater strength, larger and stronger bones, higher circulating haemoglobin as well as mental and/or psychological differences. After completion of male puberty, circulating testosterone levels in men are consistently 10-15 times higher than in children or women at any age." (68)

115. To illustrate, Figure 3 of Handelsman (2017) below indicates, "the age trends in hand-grip strength showed a difference in hand-grip strength commencing from the age of 12.8 years onwards (Figure 3). Prior to the age of 13 years, boys had a marginally significant greater grip strength than girls (n=45, t=2.0, P=.026), but after the age of 13 years, there was a strong significant relationship between age and difference in grip strength (n=18, r=.89, P<.001)." (70)



116. Handelsman (2017) in particular focuses on the correlation between the development of this performance gap and the progress of male adolescence and circulating testosterone levels in boys. "The strength of the present study is that it includes a wide range of swimming as well as track and field running and jumping events as well as strength for nonathletes for males and females across the ages spanning the onset of male puberty. The similar timing of the gender divergence in each of these settings to that of the rise in circulating testosterone to adult male levels strongly suggests that they all reflect the increase in muscular size and strength although the impact of other androgen-dependent effects on bone, haemoglobin and psychology may also contribute." (71-72)

117. "In this study, the timing and tempo of male puberty effects on running and jumping performance were virtually identical and very similar to those in swimming events. Furthermore, these coincided with the timing of the rise in circulating testosterone due to male puberty. In addition to the strikingly similar timing and tempo, the magnitude of the effects on performance by the end of this study was 10.0% for running and 19.3% for jumping, both consistent with the gender differences in performance of adult athletes previously reported to be 10%-12% for running and 19% for jumping." (71)

118. "In the swimming events, despite the continued progressive improvements in individual male and female event records, the stability of the gender difference over 35 years shown in this study suggests that the gender differences in performance are stable and robust." (71)

119. "The similar time course of the rise in circulating testosterone with that of the gender divergences in swimming and track and field sports is strongly suggestive that these effects arise from the increase in circulating testosterone from the start of male puberty." (71) "It

is concluded that the gender divergence in athletic performance begins at the age of 12-13 years and reaches adult plateau in the late teenage years. Although the magnitude of the divergence varies between athletic skills, the timing and tempo are closely parallel with each other and with the rise in circulating testosterone in boys during puberty to reach adult male levels." (72)

120. Handelsman (2017) notes several specific physiological effects of male levels of circulating testosterone that are relevant to athletic performance:

a. "Adult male circulating testosterone also has marked effects on bone development leading to longer, stronger and denser bone than in age-matched females." (71)

b. "A further biological advantage of adult male circulating testosterone concentrations is the increased circulating haemoglobin. Men have ~10 g/L greater haemoglobin than women with the gender differences also evident from the age of 13-14 years." (71)

121. Handelsman (2017) also observes that "exposure to adult male testosterone concentrations is likely to produce some mental or psychological effects. However, the precise nature of these remains controversial and it is not clear whether, or to what extent, this contributes to the superior elite sporting performance of men in power sports compared with the predominant effects on muscle mass and function." (71)

I. Centers for Disease Control & Prevention, "National Health Statistics Reports Number 122," CDC (2018):

122. To obtain data on height, weight, and body mass differences between men and women, I accessed the "National Health Statistics Reports Number 122" published by the

Centers for Disease Control & Prevention, at https://www.cdc.gov/nchs/data/nhsr/nhsr122-508.pdf, which is based on data through 2016.

123. The average height for a U.S. adult man is 5 feet 9 inches and for a U.S. adult woman the average height is 5 feet 4 inches. (3)

124. The average weight for a U.S. adult man is 197.8 lbs. and for a U.S. adult woman the average weight is 170.5 lbs. (6)

125. The average body mass index for a U.S. adult man is 29.1 kg/m^2, and the average body mass index for a U.S. adult woman is 29.6 kg/m^2. (3)

III. Administration of cross-sex hormones to men, or adolescent boys, after male puberty does not eliminate their performance advantage over women, or adolescent girls, in almost all athletic contests.

126. At the collegiate level, the "NCAA Policy on Transgender Student-Athlete Participation" requires only that such males be on unspecified and unquantified "testosterone suppression treatment" for "one calendar year" prior to competing in women's events.

127. Studies have demonstrated that hormone administration of testosterone suppression does not eliminate the physical advantages males have over females in athletics. Although such studies have not focused specifically on elite athletes, there is no scientific evidence or principle suggesting that the effects of hormone administration of testosterone suppression on elite athletes should be different than they are in the general population.

128. It is obvious that some effects of male puberty that confer advantages for athletic performance—in particular bone size and configuration—cannot be reversed once they have occurred.

129. In addition, some studies have now determined that other physiological advantages conferred by male puberty are also not fully reversed by later hormonal treatments

associated with gender transition. Specifically, studies have shown that the effects of puberty in males including increased muscle mass, increased bone mineral density, increased lung size, and increased heart size, are not completely reversed by suppressing testosterone secretion and administering estrogen during gender transition procedures in males.

130. For example, suppressing testosterone secretion and administering estrogen in post pubescent males does not shrink body height to that of a comparably aged female, nor does it reduce lung size or heart size. Indeed, while testosterone suppression and estrogen administration reduce the size and density of skeletal muscles, the muscles remain larger than would be expected in a typical female even when matched for body height or mass. A general tenet of exercise science is that larger muscles are stronger muscles due to larger muscles containing more contractile proteins. Thus, while gender transition procedures may impair a male's athletic potential, in my opinion it is still highly unlikely to be reduced to that of a comparably aged and trained female due to these physiological factors.

131. Supporting my opinion in this regard, at least two recent prospective studies involving substantial numbers of subjects have found that measured strength did not decrease, or decreased very little, in male-to-female subjects after a full year of hormone therapy including testosterone suppression, leaving these populations with a large strength advantage over baseline female strength.

132. I review relevant findings in more detail below.

A. Handelsman, Hirschberg, et al. (2018):

133. Handelsman et al. (2018) note that in "transgender individuals, the developmental effects of adult male circulating testosterone concentrations will have established the sex difference in muscle, hemoglobin, and bone, some of which is fixed and irreversible

(bone size) and some of which is maintained by the male circulating testosterone concentrations (muscle, hemoglobin)." (824)

134. "[D]evelopmental bone effects of androgens are likely to be irreversible." (818)

135. With respect to muscle mass and strength, Handelsman et al. (2018) observe that suppression of testosterone in males to levels currently accepted for transgender qualification to compete in women's events will still leave those males with a large strength advantage. "Based on the established dose-response relationships, suppression of circulating testosterone to <10 nmol/L would not eliminate all ergogenic benefits of testosterone for athletes competing in female events. For example, according to the Huang *et al.* [] study, reducing circulating testosterone to a mean of 7.3 nmol/L would still deliver a 4.4% increase in muscle size and a 12% to 26% increase in muscle strength compared with circulating testosterone at the normal female mean value of 0.9 nmol/L. Similarly, according to the Karunasena *et al*. [] study, reducing circulating testosterone concentration to 7 nmol/L would still deliver 7.8% more circulating hemoglobin than the normal female mean value. Hence, the magnitude of the athletic performance advantage in DSD athletes, which depends on the magnitude of elevated circulating testosterone concentrations, is considerably greater than the 5% to 9% difference observed in reducing levels to <10 nmol/L." (821)

B. Gooren (2011):

136. In addition to noting that the length and diameter of bones is unchanged by post-pubertal suppression of androgens (including testosterone) (653), Gooren found that "[i]n spite of muscle surface area reduction induced by androgen deprivation, after 1 year the mean muscle surface area in male-to- female transsexuals remained significantly greater than in untreated

female-to-male transsexuals." (653) "Untreated female-to-male transsexuals" refers to biological females, who will have hormonal levels ordinarily associated with women.

137. As I have explained above, greater muscle surface area translates into greater strength assuming comparable levels of fitness.

C. Knox, Anderson, et al. (2019):

138. In their recent article, Knox et al. reviewed the physiological effects of reducing circulating testosterone levels below 10nmol/L, the level current accepted by the International Olympic Committee (IOC) (2015) guidelines as adequate to permit males to enter as women in Olympic competition.

139. Knox et al. note the unarguable fact that 10nmol/L is a far higher level of circulating testosterone than occurs in women, including elite women athletes. "Transwomen [meet IOC guidelines] to compete with testosterone levels just under 10 nmol/L. This is more than five times the upper testosterone level (1.7 nmol/L) of healthy, premenopausal elite cis-women athletes. Given that testosterone (as well as other elements stemming from Y-chromosome-dependent male physiology) provides an all-purpose benefit in sport, suggests that transwomen have a performance advantage." (398)

140. As to **bone strength**, Knox et al. report that a "recent meta-analysis shows that hormone therapy provided to transwomen over 2 years maintains bone density so bone strength is unlikely to fall to levels of cis-women, especially in an elite athlete competing and training at high intensity. Increased bone strength also translates into protection against trauma, helping with recovery and prevention of injury." (398)

141. Based on a review of multiple studies, Knox et al. report that, in addition to bone size, configuration, and strength, "hormone therapy will not alter … **lung volume or heart size**

of the transwoman athlete, especially if [that athlete] transitions postpuberty, so natural advantages including joint articulation, stroke volume and maximal oxygen uptake will be maintained." (398)

142. With respect to **muscle mass and strength**, Knox et al. found that "healthy young men did not lose significant muscle mass (or power) when their circulating testosterone levels were reduced to 8.8 nmol/L (lower than the IOC guideline of 10 nmol/L) for 20 weeks. Moreover, retention of muscle mass could be compensated for by training or other ergogenic methods. In addition, the phenomenon of muscle memory means muscle mass and strength can be rebuilt with previous strength exercise making it easier to regain muscle mass later in life even after long intervening periods of inactivity and mass loss." (398)

143. Indeed, Knox et al. observe that oestradiol—routinely administered as part of hormone therapy for transwomen—is actually known to *increase* muscle mass, potentially providing an *additional* advantage for these athletes over women. "While testosterone is the well-recognised stimulator of muscle mass gain, administration of oestradiol has also been shown to activate muscle gain via oestrogen receptor-β activation. The combination of oestradiol therapy and a baseline testosterone of 10 nmol/L arguably provides transwomen athletes with an added advantage of increased muscle mass, and therefore power." (398)

144. Summing up these facts, Knox et al. observe: "A transwoman athlete with testosterone levels under 10 nmol/L for 1 year will retain at least some of the physiological parameters that underpin athletic performance. This, coupled with the fact that [under IOC rules] transwomen athletes are allowed to compete with more than five times the testosterone level of a cis-woman, suggests transwomen have a performance advantage." (398) Indeed, considering the magnitude of the advantages involved, Knox et al. conclude that the physiological advantages

resulting from male puberty that are not negated by post-pubertal hormonal therapy "provide a strong argument that transwomen have an intolerable advantage over cis-women." (399)

D. Gooren & Bunck (2004):

145. Measuring the concrete significance of the fact that bone size and configuration cannot be changed after puberty, Gooren and Bunk reported that "[Male-to-female transsexuals] were on average 10.7 cm taller (95% CI 5.4–16.0 cm) than [female-to-male transsexuals] (7)." (427)

146. With respect to muscle mass, Gooren and Bunk reported what other authors have since described in more detail: "After 1 year of androgen deprivation, mean muscle area in [male-to-female transsexuals] had decreased significantly but remained significantly greater than in [female-to-male transsexuals] before testosterone treatment." (427) To be clear, female-to-male transsexuals "before testosterone treatment" are biological females with natural female hormone levels.

> "The conclusion is that androgen deprivation in [male-to-female transsexuals] increases the overlap in muscle mass with women but does not reverse it, statistically." (425) In other words, for the overall sample of 19 male-to female transsexuals, before ("306.9 ± 46.5 cm^2") and after ("277.8 ± 37.0 cm^2") 1 year of cross-sex hormone administration these subjects had statistically significantly more muscle mass than the 17 untreated females ("238.8 ± 33.1 cm^2") (427). Before treatment, an unstated number of male-to-female transsexuals on the low end of the range for muscle mass in this sample were similar to an unstated number of untreated females on the high end of the range for muscle mass. As the muscle mass decreased in male-to-female transsexuals due to cross-sex hormone treatment there were an unstated number of male-to-female subjects whose

muscle mass was similar to the untreated women on the high end of the range for muscle mass. But, the overlap in muscle mass between male-to-female and untreated female subjects was insufficient to alter the statistical analysis.

147. Gooren and Bunk provide an insightful conclusion regarding whether it is fair for male-to-female transgender individuals to compete with biological females "The question of whether reassigned M–F can fairly compete with [biological] women depends on what degree of arbitrariness one wishes to accept". (425)

E. Wiik et al. (2020):

148. Taking measurements one month after start of testosterone-suppression in male-to-female subjects, and again 3 and 11 months after start of feminizing hormone replacement therapy in these subjects, Wiik et al. found that total lean tissue (i.e. primarily muscle) did not decrease significantly across the entire period. And even though they observed a small decrease in thigh muscle mass, they found that isometric strength levels measured at the knee "were maintained over the [study period]." (e808) "At T12 [the conclusion of the one-year study], the absolute levels of strength and muscle volume were greater in [male-to-female subjects] than in [female-to-male subjects] and CW [women who had not undergone any hormonal therapy]." (e808)

149. While female-to-male subjects "experienced robust changes in lower-limb muscle mass and strength" after 11 months of testosterone injection (e812), even after the female-to-male subjects had undergone testosterone injection, and the male-to-female subjects had undergone testosterone suppression and feminizing hormone replacement therapy, the male-to-female subjects "still had larger muscle volumes and quadriceps area" (e811).

150. In other words, biologically male subjects remained stronger than biologically female subjects after undergoing a year of testosterone suppression, and even remained stronger than biologically female subjects who had undergone 11 months of testosterone-driven "robust" increases in muscle mass and strength. I note that outside the context of transgender athletes, the testosterone-driven increase in strength enjoyed by these female-to-male subjects would constitute a disqualifying doping violation under all league anti-doping rules with which I am familiar.

F. Scharff et al. (2019):

151. Scharff et al. measured grip strength in a large cohort of male-to-female subjects from before the start of hormone therapy through one year of hormone therapy. The hormone therapy included suppression of testosterone to less than 2 nml/L "in the majority of the transwomen," (1024), as well as administration of estradiol (1021). These researchers observed a small decrease in grip strength in these subjects over that time, but mean grip strength of this group remained far higher than mean grip strength of females—specifically, "After 12 months, the median grip strength of transwomen [male-to-female subjects] still falls in the 95th percentile for age-matched females." (1026)

152. As further evidence that male-to-female transgender treatment does not negate the inherent athletic performance advantages of a post-pubertal male, I present race times for the well-publicized sports performance of Cece Telfer. In 2016 and 2017 Cece Telfer competed as Craig Telfer on the Franklin Pierce University men's track team being ranked 200th and 390th (respectively) against other NCAA Division 2 men and did not qualify for the National Championships in any events. Cece Telfer did not compete in the 2018 season while undergoing male-to-female transgender treatment (per NCAA policy). In 2019 Cece Telfer competed on the

Franklin Pierce University women's team, qualified for the NCAA Division 2 Track and Field National Championships, and placed 1st in the women's 400 meter hurdles and placed third in the women's 100 meter hurdles. (for examples of the media coverage of this please see https://www.washingtontimes.com/news/2019/jun/3/cece-telfer-franklin-pierce-transgender-hurdler-wi/ last accessed May 29, 2020. https://www.newshub.co.nz/home/sport/2019/06/athletics-transgender-woman-cece-telfer-who-previously-competed-as-a-man-wins-ncaa-track-championship.html last accessed May 29, 2020.)

153. The table below shows the best collegiate performance times from the combined 2015 and 2016 seasons for Cece Telfer when competing as a man (Craig Telfer) in men's events, and the best collegiate performance times from the 2019 season when competing as a woman in women's event. Comparing the times for the running events (in which male and female athletes run the same distance) using a two tailed paired sample test there is no statistical difference (P=0.51) between the times. Calculating the difference in time between the male and female times for the best performances in the same running events and dividing that difference by the male performance times, as a female Cece Telfer performed an average of 0.22% *faster* as a female. (Comparing the performance for the hurdle events (marked with H) is of questionable validity due to differences between men's and women's events in hurdle heights and spacing, and distance for the 110m vs. 100 m.) While this is simply one example, and does not represent a controlled experimental analysis, this information provides some evidence that male-to-female transgender treatment does not negate the inherent athletic performance advantages of a post-pubertal male. (these times were obtained from https://www.tfrrs.org/athletes/6994616/Franklin_Pierce/CeCe_Telfer.html and https://www.tfrrs.org/athletes/5108308.html, last accessed May 29, 2020)

As Craig Telfer (male athlete)		As Cece Telfer (female athlete)	
Event	Time (seconds)	Event	Time (seconds)
55	7.01	55	7.02
60	7.67	60	7.63
100	12.17	100	12.24
200	24.03	200	24.30
400	55.77	400	54.41
55 H †	7.98	55 H†	7.91
60 H †	8.52	60 H†	8.33
110 H†	15.17	100 H†	13.41*
400 H‡	57.34	400 H‡	57.53**

* women's 3rd place, NCAA Division 2 National Championships
** women's 1st place, NCAA Division I2 National Championships
† men's hurdle height is 42 inches with differences in hurdle spacing between men and women
‡ men's hurdle height is 36 inches, women's height is 30 inches with the same spacing between hurdles

G. Johanna Harper. (2015):

154. This article is oft cited as evidence supporting a lack of performance advantage for male-to-female transgender athletes (*for an example see the Expert Declaration by Joshua D. Safer, MD, FACP, FACE. Case 1:20-cv-00184-CWD Document 22-9, point 51*). This article purports to show that male-to-female transgender distance runners do not retain post-pubertal athletic advantages over biological females. However, this paper has numerous methodical shortcomings rendering the data and conclusions to be of little to no scientific validity. Herein I provide a detailed critique of a number of the methodical shortcomings of this paper.

155. Of major concern is that the paper does not mention any type of approval from a research ethics committee, documentation of informed consent from the participants, or otherwise state that the study was conducted in accordance with the ethical principles of the World Medical Association Declaration of Helsinki, which raises the specter of overall ethical concerns with this paper (This may simply be an oversight on the part of the journal in not

requiring such a statement, but such an oversight is very unusual given the publication date of 2015). As the data were gathered with the intent of contributing to the scientific knowledge, and there was interaction between the researcher and the subjects with exchange of identifiable and sensitive information, Institutional Review Board approval and documentation of consent are necessary for this type of project.

156. The author states that "The first problem is how to formulate a study to create a meaningful measurement of athletic performance, both before and after testosterone suppression. No methodology has been previously devised to make meaningful measurements." (2) This statement is not correct as there are innumerable publications with validated methodology for comparing physical fitness and/or athletic performance between people of different ages, sexes (some of which have previously been discussed), medical conditions, and before and after medical treatment, any of which could easily have been used with minimal or no adaptation for the purposes of this study (many even before the initiation of the Harper study, which apparently started in 2006).

157. The overall methods as explained within the manuscript are of limited scientific validity and reliability, starting with subject recruitment. The author states "The collection process consisted of seeking out female transgender distance runners, mostly online, and then asking them to submit race times. Even in 2014 few people are open about being transgender, so the submission of race times represented a large leap of faith for the participants." (3) There is no further information regarding how the subjects were recruited (i.e. sampling techniques). Furthermore, based on this description of sampling techniques there is no way to know if these 8 subjects are in any way representative of any population of men, women, or transgender individuals, and especially the overall transgender distance running population. For example,

what websites were used to identify possible subjects? How were the subjects solicited to participate? Was any compensation or coercion offered to the subjects? What inclusion or exclusion criteria were used in subject selection? How were the subjects who were not recruited online identified and enrolled into the research? How many were recruited online vs. not online? Furthermore, no indication is given if the subjects have undergone only hormone treatment, surgical treatment, or both. Furthermore, there is no indication of any verification of testosterone concentrations, compliance with hormone treatments, or other relevant endocrine or transgender treatment information. Lastly, no descriptive data are provided for the subjects' body height, body mass, or other relevant anthropometric characteristics.

158. Similar to the sampling techniques the methods for collecting race times are lacking in validity, reliability, or detailed description. The author states "Race times from eight transgender women runners were collected over a period of seven years and, when possible, verified." And "When possible, race times were then verified using online services listing race results. For six of the eight runners, online checking made it possible to verify approximately half of the submitted times. Two of the subjects, runners three and four, would only participate anonymously, creating an ethical dilemma over the use of their times, versus respect their privacy." (3) No further information regarding which race times were verified is presented, thus the verified race times could be only pre-transition, only post transition, all coming from 3 of the subjects, or some combination thereof. The validity and reliability of self-reported data are overall very questionable, which the author acknowledges by stating "The times submitted by the eight runners were self-selected and self-reported. The self- reporting by the subjects certainly affects the strength of the findings. As mentioned previously, almost half of the race times were double checked by the author for accuracy. None of the subjects incorrectly reported any result"

(6). However, verifying "almost half" of the race times does not validate the other "almost half." The author does not state which race times the runners were asked to self-report (i.e. these could have been the slowest times as a man and the fastest times as a woman, or vice versa. Or the reported races time could be some form of non-representative sample of the subjects' race times). As some of the data represent a span of 29 years between reported race times, and the mean time between reported race times is 7.3 ± 8.4 years the accuracy of the non-verified self-reported race times are very questionable [The means ± sd are not presented in the paper; they were calculated by the author of this declaration]. The author further states that only three of the pairs of race times "were run over the same course within three years' time and represent the best comparison points" (5) (i.e. Runner No. 4 provided one pair of pre-post transition 5K times, Runner No. 6 provided one pair of pre-post transition 10K times, and Runner No 6 provided one pair of pre-post transition Half-marathon times). Runner No 4 was one of the previously described "ethical dilemma" (3) subjects with no verified race times. Once again, it is not stated if any of "the best comparison points" (5) represents verified data. Furthermore, while the race may have been run over the same course, no mention of environmental conditions for the comparison performance is made. To put this in perspective, the 2018 Boston Marathon was run in rain and headwinds resulting in a men's winning time of 2:15:54 (the slowest time since 1976) and a women's winning time of 2:39:54 (the slowest time for a women's winner since 1978). To help further illustrate the challenges in year to year comparison of race time that may be exacerbated by weather, in 2017 the men's winning time for the Boston Marathon was 2:09:37 and the women's winning time was 2:21:52.

159. The author notes that "both runner two and runner six reported stable training patterns over this time range" (5), but once again, there is no indication of how these data were

collected or verified. Furthermore, what does a "stable training pattern mean"? Is it mileage, or pace, or combination of training techniques? This also further illustrates the methodological weaknesses in the study as runner two did not provide times for the "same course within three years' time", which, to quote the author "represent the best comparison points".

160. There is no experimental control for, or mention of, habitual nutrition, pre-event or during-event nutrition, any which (especially hydration and carbohydrate intake) can have a major impact on the outcome of endurance competition.

161. The description of the statistical analysis is insufficient. The author states that "Two tailed t tests were run on both the mean and peak AGs." (5) This is an ambiguous statement. Typically an author would report what kind of t-test was performed. Were these paired sample t-tests, independent sample t-tests, or one-sample t-tests?

162. Despite these methodological shortcomings, the author makes some insightful statements in the discussion. In the discussion section of the paper the author states "Transgender women are taller and larger, on average, than 46,XX women [], and these differences probably would result in performance advantages in events in which height and strength are obvious precursors to success" (7). The author further reasonably states that "It should be noted that this conclusion only applies to distance running and the author makes no claims as to the equality of performances, pre and post gender transition, in any other sport. As such, the study cannot, unequivocally, state that it is fair to allow transgender women to compete against 46,XX women in all sports…" to which the author adds "…although the study does make a powerful statement in favor of such a position."(8) This latter statement cannot be supported based on the data contained in this paper or any presently known research.

Conclusion

163. Once again, based on my professional familiarity with exercise physiology and my review of the currently available science, including that contained in the sources I cite and summarize in this declaration, and the competition results and records presented here, I offer three primary professional opinions:

a. At the level of elite, sub elite, high school, and recreational competition, men or boys have an advantage over comparably aged women or girls, in almost all athletic contests;

b. Biological male physiology and anatomy is the basis for the performance advantage that men or boys have over women or girls, in almost all athletic contests; and

c. Administration of androgen inhibitors and cross-sex hormones to men, or adolescent boys, after male puberty, and administration of testosterone to women or adolescent girls, after female puberty, does not eliminate the performance advantage of men or adolescent boys over women or adolescent girls in almost all athletic contests.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed this 3rd day of June, 2020.

/s/ Gregory A. Brown
Professor Gregory A. Brown, Ph.D.

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that on June 4, 2020, I electronically filed the foregoing with the Clerk of the Court using the CM/ECF system which sent a Notice of Electronic Filing to the following persons:

Richard Eppink
AMERICAN CIVIL LIBERTIES UNION
OF IDAHO FOUNDATION
REppink@acluidaho.org

Gabriel Arkles
James Esseks
Chase Strangio
AMERICAN CIVIL LIBERTIES FOUNDATION
garkles@aclu.org
jesseks@aclu.org
cstrangio@aclu.org

Kathleen Hartnett
Elizabeth Prelogar
Andrew Barr
COOLEY LLP
khartnett@cooley.com
eprelogar@cooley.com
abarr@cooley.com

Catherine West
LEGAL VOICE
cwest@legalvoice.org

Attorneys for Plaintiffs

Matthew K. Wilde
BOISE STATE UNIVERSITY
OFFICE OF GENERAL COUNSEL
mattwilde@boisestae.edu

Attorney for Defendants Boise State University and Marlene Tromp

Bruce D. Skaug
Raul R. Labrador
bruce@skauglaw.com
raul@skauglaw.com

Roger G. Brooks
Jeffrey A. Shafer
ALLIANCE DEFENDING FREEDOM
rbrooks@ADFlegal.org
jshafer@ADFlegal.org

Kristen K. Waggoner
Parker Douglas
Christiana M. Holcomb
ALLIANCE DEFENDING FREEDOM
kwaggoner@ADFlegal.org
pdouglas@ADFlegal.org
cholcomb@ADFlegal.org

Attorneys for Proposed Intervenors

/s/ W. Scott Zanzig
W. SCOTT ZANZIG
Deputy Attorney General

ATTACHMENT

EXPERT DECLARATION OF GREGORY A. BROWN, Ph.D. FACSM

Hecox, et al. v. Little, et al.

Case No. 1:20-cv-00184-DCN

Gregory Allen Brown, Ph.D. FACSM

Wellness Center 221, Cushing Building
Department of Kinesiology & Sport Sciences
University of Nebraska Kearney
1410 W 26th St
Kearney, NE 68849
(308) 865 - 8333
browngа@unk.edu

Academic Preparation

Doctor of Philosophy, Iowa State University. August 2002 -- Major in Health and Human Performance, Emphasis in the Biological Bases of Physical Activity, dissertation title: "Androgenic supplementation in men: Effects of age, herbal extracts, and mode of delivery."

Master of Science, Iowa State University, May 1999 -- Major in Exercise and Sport Science, Emphasis in Exercise Physiology, thesis title: "Oral anabolic-androgenic supplements during resistance training: Effects on glucose tolerance, insulin action, and blood lipids."

Bachelor of Science, Utah State University, June 1997 -- Major in Physical Education, Emphasis in Pre-physical Therapy.

Awards

College of Education Outstanding Faculty Teaching Award. University of Nebraska at Kearney 2019

Mortar Board Faculty Excellence Honors. Xi Phi Chapter, University of Nebraska at Kearney, Honored in 2006, 2007, 2008, 2012, 2013, 2015, and 2019

Profiled in New Frontiers, the University of Nebraska Kearney annual publication highlighting excellence in research, scholarship, and creative activity. 2009, 2017

College of Education Outstanding Scholarship / Research Award. University of Nebraska at Kearney 2009, 2014

College of Education Award for Faculty Mentoring of Undergraduate Student Research University of Nebraska at Kearney, 2007, 2010, & 2013

"Pink Tie" award from the Susan G. Komen Nebraska Affiliate, for outstanding service to the Central Nebraska Race for the Cure, 2013

Star Reviewer for the American Physiological Society and Advances in Physiology Education. 2010.

Fellow of the American College of Sports Medicine. Awarded April 23, 2008

UNK Senior Appreciation Program honoree, the University of Nebraska at Kearney

Iowa State University Research Excellence Award, Iowa State University, 2002

The Zaffarano Prize for Graduate Student Research, Iowa State University, 2002

Helen Hilton Lebaron Excellence in Research Award, Dept. of Health and Human Performance, Iowa State University, 2002

Best Paper Award, 2nd Annual Education Research Exchange. Iowa State University Education Research Exchange, 2001

Helen Hilton Lebaron Excellence in Research Award, Dept. of Health and Human Performance, Iowa State University, 2000

Professional Experience

Professor: University of Nebraska Kearney, Dept. of Kinesiology and Sport Sciences (2012-)

Associate Professor: University of Nebraska Kearney, HPERLS Dept. (2007-2012)

Assistant Professor: University of Nebraska Kearney, HPERLS Dept. (2004- 2007) Full Graduate Faculty status awarded on hire, 2004

Assistant Professor: Georgia Southern University, Jiann-Ping Hsu School of Public Health. (2002-2004) Full Graduate Faculty status awarded Nov. 26, 2002

Laboratory Director: Human Performance Laboratory, Georgia Southern University, Jiann-Ping Hsu School of Public Health. (2002-2004)

Research Assistant: Exercise Biochemistry and Physiology Laboratory, Iowa State University, Department of Health and Human Performance. (1997-2002)

Graduate Teaching Assistant: Iowa State University, Department of Health and Human Performance. (1997-2002)

Temporary Instructor: Iowa State University, Department of Health and Human Performance. (1999-2002)

Temporary Adjunct Faculty: Des Moines Area Community College. (2000)

Undergraduate Teaching Intern: Department of Biology, Utah State University. (1995-1996)

Refereed Publications

1. Schneider KM and Brown GA (as Faculty Mentor). What's at Stake: Is it a Vampire or a Virus? International Journal of Undergraduate Research and Creative Activities. 11, Article 4. 2019.
2. Christner C and Brown GA (as Faculty Mentor). Explaining the Vampire Legend through Disease. UNK Undergraduate Research Journal. 23(1), 2019. *this is an on campus publication
3. Schneekloth B and Brown GA. Comparison of Physical Activity during Zumba with a Human or Video Game Instructor. 11(4):1019-1030. International Journal of Exercise Science, 2018.
4. Bice MR, Hollman A, Bickford S, Bickford N, Ball JW, Wiedenman EM, Brown GA, Dinkel D, and Adkins M. Kinesiology in 360 Degrees. International Journal of Kinesiology in Higher Education, 1: 9-17, 2017

5. Shaw I, Shaw BS, Brown GA, and Shariat A. Review of the Role of Resistance Training and Musculoskeletal Injury Prevention and Rehabilitation. Gavin Journal of Orthopedic Research and Therapy. 1: 5-9, 2016
6. Kahle A, Brown GA, Shaw I, & Shaw BS. Mechanical and Physiological Analysis of Minimalist versus Traditionally Shod Running. J Sports Med Phys Fitness. 56(9):974-9, 2016
7. Bice MR, Carey J, Brown GA, Adkins M, and Ball JW. The Use of Mobile Applications to Enhance Learning of the Skeletal System in Introductory Anatomy & Physiology Students. Int J Kines Higher Educ 27(1) 16-22, 2016
8. Shaw BS, Shaw I, & Brown GA. Resistance Exercise is Medicine. Int J Ther Rehab. 22: 233-237, 2015.
9. Brown GA, Bice MR, Shaw BS, & Shaw I. Online Quizzes Promote Inconsistent Improvements on In-Class Test Performance in Introductory Anatomy & Physiology. Adv. Physiol. Educ. 39: 63-6, 2015
10. Brown GA, Heiserman K, Shaw BS, & Shaw I. Rectus abdominis and rectus femoris muscle activity while performing conventional unweighted and weighted seated abdominal trunk curls. Medicina dello Sport. 68: 9-18. 2015
11. Botha DM, Shaw BS, Shaw I & Brown GA. Role of hyperbaric oxygen therapy in the promotion of cardiopulmonary health and rehabilitation. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). Supplement 2 (September), 20: 62-73, 2014
12. Abbey BA, Heelan KA, Brown, GA, & Bartee RT. Validity of HydraTrend™ Reagent Strips for the Assessment of Hydration Status. J Strength Cond Res. 28: 2634-9. 2014
13. Scheer KC, Siebrandt SM, Brown GA, Shaw BS, & Shaw I. Wii, Kinect, & Move. Heart Rate, Oxygen Consumption, Energy Expenditure, and Ventilation due to Different Physically Active Video Game Systems in College Students. International Journal of Exercise Science: 7: 22-32, 2014
14. Shaw BS, Shaw I, & Brown GA. Effect of concurrent aerobic and resistive breathing training on respiratory muscle length and spirometry in asthmatics. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). Supplement 1 (November), 170-183, 2013
15. Adkins M, Brown GA, Heelan K, Ansorge C, Shaw BS & Shaw I. Can dance exergaming contribute to improving physical activity levels in elementary school children? African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). 19: 576-585, 2013
16. Jarvi MB, Brown GA, Shaw BS & Shaw I. Measurements of Heart Rate and Accelerometry to Determine the Physical Activity Level in Boys Playing Paintball. International Journal of Exercise Science: 6: 199-207, 2013
17. Brown GA, Krueger RD, Cook CM, Heelan KA, Shaw BS & Shaw I. A prediction equation for the estimation of cardiorespiratory fitness using an elliptical motion trainer. West Indian Medical Journal. 61: 114-117, 2013.

18. Shaw BS, Shaw I, & Brown GA. Body composition variation following diaphragmatic breathing. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). 18: 787-794, 2012.

19. Shaw I, Shaw BS, & Brown GA. Concurrent Training and Pulmonary Function in Smokers. Int J Sports Med. 32:776-80, 2011

20. Nienhueser J, Brown, GA, Shaw BS & I Shaw. Effects of Energy Drinks on Metabolism at Rest and During Submaximal Treadmill Exercise in College Age Males. Int J Exerc Sci 4: 321-332, 2011

21. Shaw I, Shaw BS, & Brown GA. Relationship between Resistance Training and Self-Reported Habitual Nutrient Intake. South African Journal for Research in Sport, Physical Education and Recreation. 32: 109-116, 2010

22. Brown GA, Swendener AM, Shaw I, & Shaw BS. Comparison of anthropometric and metabolic responses to a short term carbohydrate restricted diet and exercise versus a traditional diet and exercise. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). 16: 535-544, 2010

23. Brown GA, Ray M, Abbey BA, Shaw BS, & Shaw I. Oxygen Consumption, Heart Rate and Blood Lactate Responses to an Acute Bout of Plyometric Depth Jumps in College Aged Men and Women. J Strength Cond Res. 24:275-82. 2010

24. Shaw I, Shaw BS, Brown GA, & Cilliers JF. Concurrent Resistance and Aerobic Training as Protection against Heart Disease. Cardiovasc J Afr 21: 196-199, 2010

25. Brown GA, Cook CM, Krueger RD, & Heelan KA Comparison of energy expenditure on a treadmill vs. an elliptical device at a self-selected exercise intensity. J Str Cond Res 24:1643-9, 2010

26. Shaw I, Shaw BS, & Brown GA. Role of Diaphragmatic Breathing and Aerobic Exercise in Improving Maximal Oxygen Consumption in Asthmatics. Science & Sports 25:139-145, 2010

27. Shaw I, Shaw BS, & Brown GA. Comparison of Resistance and Concurrent Resistance and Endurance Training Regimes in the Development of Strength. J Str Cond Res. 23: 2507-2514, 2009

28. Castell LM, Burke LM, Stear SJ, Wolfe RR, Newsholme EA, Trudeau F, Curi R, Brown GA, Vukovich MD, and DS King. BJSM reviews: A–Z of supplements: dietary supplements, sports nutrition foods and ergogenic aids for health and performance Part 2. Br. J. Sports Med. 43:807-810. 2009

29. Shaw BS, Shaw I, & Brown GA. Resistance Training and its Effect on Total, Central and Abdominal Adiposity. South African Journal for Research in Sport, Physical Education and Recreation. 31: 97-108. 2009

30. Shaw I, Shaw BS, & Brown GA. Influence of Strength Training on Cardiac Risk Prevention in Individuals without Cardiovascular Disease. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). 15: 424-432. 2009

31. Shaw BS, Shaw I, & Brown GA. Resistance Training and Predicted Risk of Coronary Heart Disease in Sedentary Males. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). Supplement: 247-257. 2009

32. Stahlnecker IV AC, Brown GA, Shaw BS, & Shaw I. Acute Effects of a Weight Loss Supplement on Resting Metabolic Rate and Anaerobic Exercise Performance. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). Supplement: 237-247. 2009

33. McWha JA, Horst S, Brown GA, Shaw I, & Shaw BS. Metabolic Changes Associated with Playing an Active Video Game Against a Human and Computer Opponent. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). Supplement: 219-228. 2009

34. Semin K, Stahlnecker IV AC, Heelan KA, Brown GA, Shaw BS, & Shaw I. Discrepancy between Training, Competition and Laboratory Measures of Maximum Heart Rate in NCAA Division 2 Distance Runners. J Sports Sci & Med. 7: 455 – 460, 2008

35. Brown GA, Rebok MP, Scott ML, Harris III J, Colaluca MK, Shaw I, & Shaw BS. Physiological and Biomechanical Responses of Running with and Without a Stroller. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). 14: 240-249, 2008

36. Brown GA, McFarland SP, Ray MW, Abbey BM, Shaw I, & Shaw BS. A Single Session of Brisk Walking Does Not Alter Blood Glucose Homeostasis in Overweight Young Men. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). 14: 250-264, 2008

37. Brown GA, Lynott F, & Heelan KA. A Service Learning Model for Teaching Fitness Assessment and Research Techniques to Undergraduate Exercise Science Students. Adv Physiol Educ. 32: 212-218, 2008

38. Carstensen C, Brown GA, Shaw I, & Shaw BS. Freely-Paced Walking in Healthy Adults Does Not Meet Minimum Intensity Guidelines for Health Improvement. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD), 14: 178-187, 2008

39. Shaw BS, Shaw I, and Brown GA. Self-Reported Dietary Intake Following Endurance, Resistance And Concurrent Endurance And Resistance Training. J Sports Sci & Med 7: 255-259, 2008

40. Brown, GA. Teaching skeletal muscle adaptations to aerobic exercise using an APS classic paper by Dr. Philip Gollnick and colleagues. Adv Physiol Educ. 30: 113-118, 2006

41. Brown GA, Vukovich MD, & King DS. Testosterone Prohomone Supplements. Med. Sci. Sports Exerc. Med Sci Sports Exerc. 38: 1451-1461, 2006

42. Brown GA, & MacKenzie D. Resistance Exercise Does Not Change The Hormonal Response To Sublingual Androstenediol. Eur J Appl Physiol. 97:404-412, 2006

43. Brown GA, Vukovich MD, and King DS. Urinary excretion of steroid metabolites following chronic androstenedione ingestion. J. Clin. Endocrinol. Metab. 12:6235 – 6338, 2004

44. Brown GA, Dewey JC, Brunkhorst J, Vukovich MD, & King DS. Changes in serum testosterone and estradiol concentrations following acute androstenedione ingestion in young women. Horm Metab Res. 1:62-66, 2004

45. Kohut ML, Thompson JR, Campbell J, Brown GA, Vukovich MD, Jackson DA, & King DS. Ingestion of a Dietary Supplement Containing Dehydroepiandrosterone (DHEA) and Androstenedione Has Minimal Effect on Immune Function in Middle-Aged Men. J Am Coll Nutr. 22: 363-71, 2003

46. Brown GA, Martini ER, Roberts BS, Vukovich MD, & King DS. Acute hormonal responses to sublingual androstenediol intake in young men. J Appl Physiol. 92: 142-146, 2002.

47. Brown GA, Vukovich MD, Martini ER, Kohut ML, Franke WL, Jackson DA, & King DS. Effects of androstenedione-herbal supplements on serum sex hormone concentrations in 30-59 year old men. Int J Vitam Nutr Res. 71: 293-301, 2001

48. Brown GA, Vukovich MD, Martini ER, Kohut ML, Franke WL, Jackson DA, & King DS. Endocrine and lipid responses to chronic androstenediol-herbal supplementation in 30 to 58 year old men. J Am Coll Nutr. 20: 520-528, 2001.

49. Brown GA, Vukovich MD, Martini ER, Kohut ML, Franke ML, Jackson DA, & King DS. Endocrine response to chronic androstenedione intake in 30-56 year old men. J Clin Endocrinol Metab. 85: 4074-4080, 2000.

50. Brown GA, Vukovich MD, Reifenrath TA, Uhl NL, Parsons KA, Sharp RL, & King DS. Effects of anabolic precursors on serum testosterone concentrations and adaptations to resistance training in young men. Int J Sport Nutr Exerc Metab. 10: 342-362, 2000.

51. Brown GA, Vukovich MD, Sharp RL, Reifenrath TA, Parsons KA, & King DS. Effect of oral DHEA on serum testosterone and adaptations to resistance training in young men. J Appl Physiol. 87: 2274-2283, 1999.

52. King DS, Sharp RL, Vukovich MD, Brown GA, Reifenrath TA, Uhl NL, & Parsons KA. Effect of oral androstenedione on serum testosterone and adaptations to resistance training in young men: a randomized controlled trial. JAMA. 281: 2020-2028, 1999.

Refereed Presentations

1. Brown GA, Jackson B, Szekely B, Schramm T, Shaw BS, Shaw I. A Pre-Workout Supplement Does Not Improve 400 M Sprint Running or Bicycle Wingate Test Performance in Recreationally Trained Individuals. Med Sci Sport Exerc. 50(5), 2932. 65th Annual Meeting of the American College of Sports Medicine. Minneapolis, MN. June 2018.

2. Paulsen SM, Brown GA. Neither Coffee Nor A Stimulant Containing “Pre-workout” Drink Alter Cardiovascular Drift During Walking In Young Men. Med Sci Sport Exerc. 50(5), 2409. 65th Annual Meeting of the American College of Sports Medicine. Minneapolis, MN. June 2018.

3. Adkins M, Bice M, Bickford N, Brown GA. Farm to Fresh! A Multidisciplinary Approach to Teaching Health and Physical Activity. 2018 spring SHAPE America central district conference. Sioux Falls, SD. January 2018.

4. Shaw I, Kinsey JE, Richards R, Shaw BS, and Brown GA. Effect Of Resistance Training During Nebulization In Adults With Cystic Fibrosis. International Journal of Arts & Sciences' (IJAS). International Conference for Physical, Life and Health Sciences which will be held at FHWien University of Applied Sciences of WKW, at Währinger Gürtel 97, Vienna, Austria, from 25-29 June 2017.
5. Bongers M, Abbey BM, Heelan K, Steele JE, Brown GA. Nutrition Education Improves Nutrition Knowledge, Not Dietary Habits In Female Collegiate Distance Runners. Med Sci Sport Exerc. 49(5), 389. 64th Annual Meeting of the American College of Sports Medicine. Denver, CO. May 2017.
6. Brown GA, Steele JE, Shaw I, Shaw BS. Using Elisa to Enhance the Biochemistry Laboratory Experience for Exercise Science Students. Med Sci Sport Exerc. 49(5), 1108. 64th Annual Meeting of the American College of Sports Medicine. Denver, CO. May 2017.
7. Brown GA, Shaw BS, and Shaw I. Effects of a 6 Week Conditioning Program on Jumping, Sprinting, and Agility Performance In Youth. Med Sci Sport Exerc. 48(5), 3730. 63rd Annual Meeting of the American College of Sports Medicine. Boston, MA. June 2016.
8. Shaw I, Shaw BS, Boshoff VE, Coetzee S, and Brown GA. Kinanthropometric Responses To Callisthenic Strength Training In Children. Med Sci Sport Exerc. 48(5), 3221. 63rd Annual Meeting of the American College of Sports Medicine. Boston, MA. June 2016.
9. Shaw BS, Shaw I, Gouveia M, McIntyre S, and Brown GA. Kinanthropometric Responses To Moderate-intensity Resistance Training In Postmenopausal Women. Med Sci Sport Exerc. 48(5), 2127. 63rd Annual Meeting of the American College of Sports Medicine. Boston, MA. June 2016.
10. Bice MR, Cary JD, Brown GA, Adkins M, and Ball JW. The use of mobile applications to enhance introductory anatomy & physiology student performance on topic specific in-class tests. National Association for Kinesiology in Higher Education National Conference. January 8, 2016.
11. Shaw I, Shaw BS, Lawrence KE, Brown GA, and Shariat A. Concurrent Resistance and Aerobic Exercise Training Improves Hemodynamics in Normotensive Overweight and Obese Individuals. Med Sci Sport Exerc. 47(5), 559. 62nd Annual Meeting of the American College of Sports Medicine. San Diego, CA. May 2015.
12. Shaw BS, Shaw I, McCrorie C, Turner S., Schnetler A, and Brown GA. Concurrent Resistance and Aerobic Training in the Prevention of Overweight and Obesity in Young Adults. Med Sci Sport Exerc. 47(5), 223. 62nd Annual Meeting of the American College of Sports Medicine. San Diego, CA. May 2015.
13. Schneekloth B, Shaw I, Shaw BS, and Brown GA. Physical Activity Levels Using Kinect™ Zumba Fitness versus Zumba Fitness with a Human Instructor. Med Sci Sport Exerc. 46(5), 326. 61st Annual Meeting of the American College of Sports Medicine. Orlando, FL. June 2014.
14. Shaw I, Lawrence KE, Shaw BS, and Brown GA. Callisthenic Exercise-related Changes in Body Composition in Overweight and Obese Adults. Med Sci Sport Exerc. 46(5), 394. 61st Annual Meeting of the American College of Sports Medicine. Orlando, FL June 2014.

15. Shaw BS, Shaw I, Fourie M, Gildenhuys M, and Brown GA. Variances In The Body Composition Of Elderly Woman Following Progressive Mat Pilates. Med Sci Sport Exerc. 46(5), 558. 61st Annual Meeting of the American College of Sports Medicine. Orlando, FL June 2014.
16. Brown GA, Shaw I, Shaw BS, and Bice M. Online Quizzes Enhance Introductory Anatomy & Physiology Performance on Subsequent Tests, But Not Examinations. Med Sci Sport Exerc. 46(5), 1655. 61st Annual Meeting of the American College of Sports Medicine. Orlando, FL June 2014.
17. Kahle, A. and Brown, G.A. Electromyography in the Gastrocnemius and Tibialis Anterior, and Oxygen Consumption, Ventilation, and Heart Rate During Minimalist versus Traditionally Shod Running. 27th National Conference on Undergraduate Research (NCUR). La Crosse, Wisconsin USA. April 11-13, 2013
18. Shaw, I., Shaw, B.S., and Brown, G.A. Resistive Breathing Effects on Pulmonary Function, Aerobic Capacity and Medication Usage in Adult Asthmatics Med Sci Sports Exerc 45 (5). S1602 2013. 60th Annual Meeting of the American College of Sports Medicine, Indianapolis, IN USA, May 26-30 3013
19. Shaw, B.S. Gildenhuys, G.A., Fourie, M. Shaw I, and Brown, G.A. Function Changes In The Aged Following Pilates Exercise Training. Med Sci Sports Exerc 45 (5). S1566 60th Annual Meeting of the American College of Sports Medicine, Indianapolis, IN USA, May 26-30 2013
20. Brown, G.A., Abbey, B.M., Ray, M.W., Shaw B.S., & Shaw, I. Changes in Plasma Free Testosterone and Cortisol Concentrations During Plyometric Depth Jumps. Med Sci Sports Exerc 44 (5). S598, 2012. 59th Annual Meeting of the American College of Sports Medicine. May 29 - June 2, 2012; San Francisco, California
21. Shaw, I., Fourie, M., Gildenhuys, G.M., Shaw B.S., & Brown, G.A. Group Pilates Program and Muscular Strength and Endurance Among Elderly Woman. Med Sci Sports Exerc 44 (5). S1426. 59th Annual Meeting of the American College of Sports Medicine. May 29 - June 2, 2012; San Francisco, California
22. Shaw B.S., Shaw, I., & Brown, G.A. Concurrent Inspiratory-Expiratory and Aerobic Training Effects On Respiratory Muscle Strength In Asthmatics. Med Sci Sports Exerc 44 (5). S2163. 59th Annual Meeting of the American College of Sports Medicine. May 29 - June 2, 2012; San Francisco, California
23. Scheer, K., Siebrandt, S., Brown, G.A, Shaw B.S., & Shaw, I. Heart Rate, Oxygen Consumption, and Ventilation due to Different Physically Active Video Game Systems. Med Sci Sports Exerc 44 (5). S1763. 59th Annual Meeting of the American College of Sports Medicine. May 29 - June 2, 2012; San Francisco, California
24. Jarvi M.B., Shaw B.S., Shaw, I., & Brown, G.A. (2012) Paintball Is A Blast, But Is It Exercise? Heart Rate and Accelerometry In Boys Playing Paintball. Med Sci Sports Exerc 44 (5). S3503. 59th Annual Meeting of the American College of Sports Medicine. May 29 - June 2, 2012; San Francisco, California
25. Shaw, I., Shaw, B.S., and Brown G.A. Effort-dependent Pulmonary Variable Improvements Following A Novel Breathing Retraining Technique In Asthmatics. Med Sci Sports Exerc

43 (5). S617, 2011. 58th Annual Meeting of the American College of Sports Medicine. May 31-June 4, 2011 Denver, Colorado

26. Brown G.A. Shaw, B.S., and Shaw, I. Exercise and a Low Carbohydrate Diet Reduce Body Fat but Not PYY and Leptin Concentrations. Med Sci Sports Exerc 43 (5). S4627, 2011. 58th Annual Meeting of the American College of Sports Medicine. May 31-June 4, 2011 Denver, Colorado
27. Shaw, B.S., Shaw, I, and Brown G.A. Pulmonary Function Changes In Response To Combined Aerobic And Resistance Training In Sedentary Male Smokers. Med Sci Sports Exerc 43 (5). S492, 2011. 58th Annual Meeting of the American College of Sports Medicine. May 31-June 4, 2011 Denver, Colorado
28. Heiserman, K., Brown G.A., Shaw, I., and Shaw, B.S. Seated Weighted Abdominal Exercise Activates the Hip Flexors, But Not Abdominals, More Than Unweighted Crunches. A Med Sci Sports Exerc 43 (5). S277, 2011 58th Annual Meeting of the American College of Sports Medicine. May 31-June 4, 2011 Denver, Colorado
29. Brown, G.A., Nienhueser, J., Shaw, I., and Shaw, B.S. Energy Drinks Alter Metabolism at Rest but not During Submaximal Exercise in College Age Males. Med Sci Sports Exerc. 42 (5): S1930. 57th Annual Meeting American College of Sports Medicine, June 1-5, 2010. Baltimore, MD
30. Shaw, I, Shaw, B.S., and Brown G.A. Abdominal and Chest Wall Compliance in Asthmatics: Effects of Different Training Modes. Med Sci Sports Exerc. 42 (5): S1588. 57th Annual Meeting American College of Sports Medicine, June 1-5, 2010. Baltimore, MD.
31. Shaw, B.S., Shaw, I, and Brown G.A. Exercise Effects on Lipoprotein Lipids in the Prevention of Cardiovascular Disease in Sedentary Males Smokers. Med Sci Sports Exerc. 42 (5): S1586. 57th Annual Meeting American College of Sports Medicine, June 1-5, 2010. Baltimore, MD.
32. Brown, G.A. Collaborative Research at a Primarily Undergraduate University. Med Sci Sports Exerc. 42 (5): S424. 57th Annual Meeting American College of Sports Medicine, June 1-5, 2010. Baltimore, MD.
33. Nienhueser, J., Brown, G.A., Effects of Energy Drinks on Resting and Submaximal Metabolism in College Age Males. NCUR 24 (24th National Conference on Undergraduate Research). Missoula, MT. April 15-17, 2010
34. Brown, G.A., N. Dickmeyer, A. Glidden, C. Smith, M. Beckman, B. Malicky, B.S. Shaw and I. Shaw. Relationship of Regional Adipose Tissue Distribution to Fasting Plasma PYY Concentrations in College Aged Females. 56th Annual Meeting American College of Sports Medicine, May 27-30, 2009. Seattle, WA. Med Sci Sports Exerc. 41 (5): S1333
35. Shaw, B.S., I. Shaw, and G.A. Brown. Contrasting Effects Of Exercise On Total And Intra-abdominal Visceral Fat. 56th Annual Meeting American College of Sports Medicine, May 27-30, 2009. Seattle, WA. Med Sci Sports Exerc. 41 (5): S1718
36. Shaw, I., B.S. Shaw, and G.A. Brown. Role of Endurance and Inspiratory Resistive Diaphragmatic Breathing Training In Improving Asthmatic Symptomology. 56th Annual

Meeting American College of Sports Medicine, May 27-30, 2009. Seattle, WA. Med Sci Sports Exerc. 41 (5): S2713

37. McWha, J., S. Horst, G.A. Brown, B.S. Shaw, and I. Shaw. Energy Cost of Physically Active Video Gaming Against a Human or Computer Opponent. 56th Annual Meeting American College of Sports Medicine, May 27-30, 2009. Seattle, WA. Med Sci Sports Exerc. 41 (5): S3069
38. Horst, S., J. McWha, G.A. Brown, B.S. Shaw, and I. Shaw. Salivary Cortisol and Blood Lactate Responses to Physically Active Video Gaming in Young Adults. 56th Annual Meeting American College of Sports Medicine, May 27-30, 2009. Seattle, WA. Med Sci Sports Exerc. 41 (5): S3070
39. Glidden A., M. Beckman, B. Malciky, C. Smith, and G.A. Brown. Peptide YY Levels in Young Women: Correlations with Dietary Macronutrient Intake and Blood Glucose Levels. 55th Annual Meeting American College of Sports Medicine, May 28-31, 2008. Indianapolis, IN. Med Sci Sports Exerc. 40 (5): S741
40. Smith C., Glidden A. M. Beckman, B. Malciky, and G.A. Brown. Peptide YY Levels in Young Women: Correlations with Aerobic Fitness & Resting Metabolic Rate. 55th Annual Meeting American College of Sports Medicine, May 28-31, 2008. Indianapolis, IN. Med Sci Sports Exerc. 40 (5): S742
41. Brown, G.A. M. Holoubeck, B. Nylander, N. Watanabe, P. Janulewicz, M. Costello, K.A. Heelan, and B. Abbey. Energy Costs of Physically Active Video Gaming in Children: Wii Boxing, Wii tennis, and Dance Dance Revolution. 55th Annual Meeting American College of Sports Medicine, May 28-31, 2008. Indianapolis, IN. Med Sci Sports Exerc. 40 (5): S2243
42. McFarland, S.P. and G.A. Brown. One Session of Brisk Walking Does Not Alter Blood Glucose Homeostasis In Overweight Young Men. 53rd annual meeting of the American College of Sports Medicine, Denver, CO. Med Sci Sports Exerc 38: S205, 2006
43. Stahlnecker IV, A.C. and G.A. Brown Acute Effects of a Weight Loss Supplement on Resting Metabolic Rate and Anaerobic Exercise Performance. 53rd annual meeting of the American College of Sports Medicine, Denver, CO. Med Sci Sports Exerc 38: S403, 2006
44. Brown, G.A. and A. Swendener. Effects of Exercise and a Low Carbohydrate Diet on Serum PYY Concentrations 53rd annual meeting of the American College of Sports Medicine, Denver, CO.. Med Sci Sports Exerc 38: s461, 2006
45. Swendener, A.M. and G.A. Brown. Effects of Exercise Combined with a Low Carbohydrate Diet on Health. 53rd annual meeting of the American College of Sports Medicine, Denver, CO. Med Sci Sports Exerc 38: s460, 2006
46. Swendener, A.M. and G.A. Brown. Effects Of Exercise Combined With A Low Carbohydrate Diet On Health. NCUR® 20, 2006
47. Stahlnecker IV, A.C. and G.A. Brown. Acute Effects Of A Weight Loss Supplement On Resting Metabolic Rate And Anaerobic Exercise. NCUR® 20, 2006

48. Eck, L. M. and G.A. Brown. Preliminary Analysis of Physical Fitness Levels in Kinesiology Students. Southern Regional Undergraduate Honors Conference. March 31, 2005.

49. Brown, G.A., J.N. Drouin, and D. MacKenzie. Resistance Exercise Does Not Change The Hormonal Response To Sublingual Androstenediol. 52nd Annual Meeting of the American College of Sports Medicine, June 1-4, 2005, Nashville, TN. Med Sci Sports Exerc 37(5): S40, 2005

50. Brown, G.A., M.P Rebok, M.L. Scott, M.K. Colaluca, and J Harris III. Economy of Jogging Stroller Use During Running. 51st Annual Meeting of the American College of Sports Medicine, June 2-5, 2004, Indianapolis, IN. Med Sci Sports Exerc 36(5): S1714, 2004

51. M.P. Rebok, M.L. Scott, J. Harris III, M.K. Colaluca, and G.A. Brown. Economy of Jogging Stroller use During Running. Georgia Southern University Legislative Wild Game Supper, 2004.

52. M.P. Rebok, M.L. Scott, J. Harris III, M.K. Colaluca, and G.A. Brown. Energy cost of jogging stroller use during running. Annual Meeting of the Southeastern Chapter of the American College of Sports Medicine, 2004.

53. Brown, G.A., Effect of 8 weeks androstenedione supplementation and weight training on glucose tolerance and isokinetic strength. Annual Meeting of the Southeastern Chapter of the American College of Sports Medicine, 2004.

54. Brown, G.A., Vukovich, M.D., Kohut, M.L., Franke, W.D., Jackson, D.A., King, D.S., and Bowers, L.D. Urinary excretion of steroid metabolites following chronic androstenedione ingestion. 50th Annual Meeting of the American College of Sports Medicine, May 27-31 2003, San Francisco, CA. Med Sci Sports Exerc 35(5): S1835

55. Brown, G.A., E.R. Martini, B.S. Roberts, M.D. Vukovich, and D.S. King. Effects of Sublingual androstenediol-cyclodextrin on serum sex hormones in young men. 48th Annual Meeting American College of Sports Medicine, May 30 – June 2, 2001. Baltimore, MD. Med Sci Sports Exerc. 33(5): S1650

56. Kohut, M.L., J.R. Thompson, J. Campbell, G.A. Brown, and D.S. King. Ingestion of a dietary supplement containing androstenedione and dehydroepiandrosterone (DHEA) has a minimal effect on immune response. International Society of Exercise and Immunology, 3rd Annual Convention May 29-30, 2001. Baltimore, MD. Med. Sci. Sports Exerc. 33(5): SISEI12

57. Brown, G.A., E.R. Martini, B.S. Roberts, and D.S. King. Effects of Sublingual androstenediol-cyclodextrin on serum sex hormones in young men. Iowa State University Educational Research Exchange, March 24, 2001. Ames, IA.

58. Martini, E.R., G.A. Brown, M.D. Vukovich, M.L. Kohut, W.D. Franke, D.A. Jackson, and D.S. King. Effects of androstenedione-herbal supplementation on serum sex hormone concentrations in 30-59 year old men. Iowa State University Educational Research Exchange, March 24, 2001. Ames, IA.

59. King, D.S., G.A. Brown, M.D. Vukovich, M.L. Kohut, W.D. Franke, and D.A. Jackson. Effects of Chronic Oral Androstenedione Intake in 30-58 year Old Men. 11th International Conference on the Biochemistry of Exercise. June 4-7, 2000. Little Rock, Arkansas

60. Brown, G.A., M.L. Kohut, W.D. Franke, D. Jackson, M.D. Vukovich, and D.S. King. Serum Hormonal and Lipid Responses to Androgenic supplementation in 30 –59 year old men. 47TH Annual Meeting American College of Sports Medicine, May 31-June 3, 2000. Indianapolis, IN. Med Sci Sports Exerc. 32(5): S486

61. Brown, G.A., T.A. Reifenrath, N.L. Uhl, R.L. Sharp, and D.S. King. Oral anabolic-androgenic supplements during resistance training: Effects on glucose tolerance, insulin action, and blood lipids. 1999 Annual Meeting American College of Sports Medicine, Seattle, WA. Med Sci Sports Exerc. 31(5): S1293

62. Reifenrath, T.A., R.L. Sharp, G.A. Brown, N.L. Uhl, and D.S. King. Oral anabolic-androgenic supplements during resistance training: Effects on body composition and muscle strength. 1999 Annual Meeting American College of Sports Medicine, Seattle, WA. Med Sci Sports Exerc. 31(5): S1292

63. King, D.S., R.L. Sharp, G.A. Brown, T.A. Reifenrath, and N.L. Uhl. Oral anabolic-androgenic supplements during resistance training: Effects on serum testosterone and estrogen concentrations. 1999 Annual Meeting American College of Sports Medicine, Seattle, WA. Med Sci Sports Exerc. 31(5): S1291

64. Parsons, K.A., R.L. Sharp, G.A. Brown, T.A. Reifenrath, N.L. Uhl, and D.S. King. Acute effects of oral anabolic-androgenic supplements on blood androgen and estrogen levels in man. 1999 Annual Meeting American College of Sports Medicine, Seattle, WA. Med Sci Sports Exerc. 31(5): S1290

Book Chapters

Brown, G.A. Chapters on Androstenedione and DHEA. In: Nutritional Supplements in Sport, Exercise and Health an A-Z Guide. edited by Linda M. Castell, Samantha J. Stear, Louise M. Burke. Routledge 2015.

Brown, G.A. Evaluating a Nutritional Supplement with SOAP Notes to Develop Critical Thinking Skills. In: Teaching Critical Thinking and Clinical Reasoning in the Health Sciences, edited by Facione NC and Facione PA. Millbrae, CA: California Academic Press 2008

Non Refereed Publications

Brown, G.A. and King, D.S. Sport Dietary Supplement Update on DHEA supplementation. Human Kinetics Publishers, Inc. October, 2000.

Brown, G.A. Getting in Shape for Paintball in the Winter. Paintball Sports International, January, 1999

Invited Presentations

Brown G.A. Collaborative experiences with researchers in South Africa. Africa Summit 2019 (March 28, 2019). Presented by the University of Nebraska and the University of Nebraska Medical Center.

Peer Reviewer for the Following Journals

Advances in Physiology Education. http://www.the-aps.org/publications/advan/

African Journal For Physical, Health Education, Recreation and Dance (AJPHERD). ISSN: 1117-4315 http://www.ajol.info/journal_index.php?jid=153

Anatomical Sciences Education. http://www.asejournal.com

Asian Journal of Sports Medicine. http://asjsm.tums.ac.ir/index.php/asjsm

CardioVascular Journal of Africa. http://www.cvjsa.co.za/

Complementary Therapies in Medicine. http://ees.elsevier.com/ctim/

European Journal of Sport Science. http://www.tandf.co.uk/journals/titles/17461391.asp

Games for Health Journal. http://www.liebertpub.com/overview/games-for-health-journal/588/

Global Journal of Health and Physical Education Pedagogy. http://js.sagamorepub.com/gjhpep

Interactive Learning Environments. https://www.tandfonline.com/toc/nile20/current

International Journal of Exercise Science. http://digitalcommons.wku.edu/ijes/

Journal of Sports Sciences. http://www.tandf.co.uk/journals/titles/02640414.html

Journal of Strength and Conditioning Research. http://journals.lww.com/nsca-jscr/pages/default.aspx

Lung. http://www.springer.com/medicine/internal/journal/408

Pediatrics. http://pediatrics.aappublications.org/

Scandinavian Journal of Medicine and Science in Sports. http://www.blackwellpublishing.com/journal.asp?ref=0905-7188

South African Journal of Diabetes and Vascular Disease http://www.diabetesjournal.co.za/

The American Journal of Physiology - Endocrinology and Metabolism. http://ajpendo.physiology.org/

The American Journal of Physiology - Heart and Circulatory Physiology. http://ajpheart.physiology.org/

The American Journal of Physiology - Regulatory, Integrative and Comparative Physiology. http://ajpregu.physiology.org/

The International Journal of Sport Nutrition & Exercise Metabolism. http://www.humankinetics.com/IJSNEM/journalAbout.cfm

The Journal of Sports Science and Medicine (JSSM) http://www.jssm.org/

The International Journal of Nutrition and Metabolism ww.academicjournals.org/IJNAM

The Open Sports Sciences Journal. http://benthamscience.com/open/tossj/index.htm

The Journal of Applied Physiology. http://jap.physiology.org/

African Health Sciences. http://www.ajol.info/index.php/ahs

Menopause. http://journals.lww.com/menopausejournal/pages/default.aspx

Membership in Professional Organizations

American College of Sports Medicine

American Physiological Society

National Strength and Conditioning Association

Graduate Student Advisement/Mentoring

Kourtney Woracek. MAEd Thesis Committee. in progress

Marissa Bongers. MAEd Thesis Committee Director. Dietary Habits and Nutrition Knowledge in Female Collegiate Distance Runners. Degree Awarded Spring 2016.

Justin Thiel. MAEd Advisor. Degree Awarded Spring 2016.

Mitchell Sasek. MAEd Advisor. Degree Awarded Summer 2015

Chad Keller. MAEd Advisor. Degree Awarded Summer 2014

Faron Klingehoffer. MAEd Advisor. Degree Awarded Summer 2014

Joe Scharfenkamp. MAEd Internship Advisor. Degree Awarded Summer 2014

Andrew Hudson. MAEd Thesis Committee. Thesis Title. valuation of Weight Loss in Parents Participating in a Pediatric Obesity Treatment Intervention Degree Awarded Fall 2012

Megan Adkins. Doctoral Dissertation Committee. An Examination of Changes in Sedentary Time with the Integration of Technology for Children Participating in a Morning Fitness Program. Degree Awarded Summer 2011

Christopher Campbell. MAEd Advisor. Degree Awarded Spring 2011

Logan Brodine. MAEd Advisor. Degree Awarded Spring 2010

Megan Costello. MAEd Thesis Committee. Changes in the Prevalence of at risk of overweight or overweight in children. Degree Awarded Spring 2009

Pamela Janulewciz, MAEd Thesis Committee. Effects of Exercise Balls as Chair Replacements in a Fourth Grade Classroom. Degree Awarded Spring 2008

Melissa Shelden. MAEd Advisor.

Michael Bell. MAEd Advisor.

Karen DeDonder. MAEd Thesis Committee. Confidence Levels of Certified Athletic Trainers Regarding Female Athlete Triad Syndrome. Degree Awarded Spring 2008

Benjamin Nylander. MAEd Comprehensive Project Director. Degree Awarded Summer 2007

Eme Ferro. MAEd advisor. Degree Awarded Summer 2007

Julie McAlpin. MAEd Thesis Committee. Children Escorted to School; effect on Parental Physical Activity Degree awarded fall 2006

Michael Ray. MAEd Comprehensive Project Director. Degree Awarded Summer 2006

Seth McFarland. MAEd Thesis Committee Director. The Effects of Exercise Duration on Glucose Tolerance and Insulin Sensitivity in Mildly Overweight Men. Degree Awarded Summer 2005

Drew McKenzie. MS Academic Advisor. Degree Awarded Spring 2005

Matthew Luckie. MS Academic Advisor. Degree Awarded Spring 2005

Todd Lane. MS Academic Advisor

Leilani Lowery. MS Internship committee, Degree Awarded Spring 2003

Johnna Ware. MS Internship committee, Degree Awarded Spring 2003

David Bass. MS Internship committee, Degree Awarded Spring 2003

Crystal Smith. MS Internship committee, Degree Awarded Summer 2003

Undergraduate Student Research Mentoring

Cassidy Johnson. Project to be determined. Undergraduate Research Fellowship (Fall 2019 -)

Taylor Wilson. A comparison of High Intensity Interval Exercise on a bicycle ergometer to a treadmill on Resting Metabolic Rate the next day. Undergraduate Research Fellowship (Fall 2018 -)

Dakota Waddell. The effect of yoga versus mindful meditation on stress in physically active and non-physically active female college-aged students Undergraduate Research Fellowship (Fall 2018 -)

Dakota Waddell. A case study of the effects of the *osteostrong* program on bone mineral density and lean body mass in a paraplegic male. Undergraduate Research Fellowship (Fall 2017 – Spring 2018)

Andrew Fields. The effects of retraining running cadence on oxygen consumption in experienced runners. Undergraduate Research Fellowship. (Fall 2017 – Spring 2019)

Logan Engel. The effects of Tart Cherry Juice on Delayed Onset Muscle Soreness following Eccentric Exercise. Undergraduate Research Fellowship. Fall 2017 -

Stephanie Paulsen. Comparing the effects of coffee to a pre-workout drink on cardiovascular drift. Summer Student Research Program. University of Nebraska Kearney. Summer 2017.

Stephanie Paulsen. Comparing the effects of coffee to a pre-workout drink on resting and exercise metabolic rate. Undergraduate Research Fellowship. Spring 2017 - .

Rachael Ernest. Comparing the effects of coffee to a pre-workout drink on resting and exercise metabolic rate. Undergraduate Research Fellowship. Fall 2016 - Spring 2017.

Aleesha Olena. Evaluating the role of body composition on abdominal muscle definition. Undergraduate Research Fellowship. University of Nebraska Kearney. Fall 2016 - Spring 2017.

Marco Escalera. Evaluating the role of body composition on abdominal muscle definition. Undergraduate Research Fellowship. University of Nebraska Kearney. Fall 2015 - Spring 2017.

Trevor Schramm. Effects of “pre-workout’ drinks on 400 m sprint performance and salivary cortisol concentrations. Undergraduate Research Fellowship. University of Nebraska Kearney. Spring 2016.

Taylor Turek. Evaluating the role of body composition on abdominal muscle definition. Undergraduate Research Fellowship. University of Nebraska Kearney. Fall 2015 - Spring 2016.

Brian Szekely. Effects of "pre-workout" drinks on Wingate test performance and blood lactate concentrations. Undergraduate Research Fellowship. University of Nebraska Kearney. Fall 2014 - Spring 2016.

Brianna Jackson. Effects of "pre-workout' drinks on 400 m sprint performance and salivary cortisol concentrations. Undergraduate Research Fellowship. University of Nebraska Kearney. Fall 2014 – Fall 2015.

Ashley Pearson. Changes in resting metabolic rate over a semester in undergraduate students. Undergraduate Research Fellowship. University of Nebraska Kearney. Fall 2013 - Spring 2015.

Tricia Young. Changes in resting metabolic rate over a semester in undergraduate students. Undergraduate Research Fellowship. University of Nebraska Kearney. Fall 2013 - Spring 2014.

Gavin Schneider. Effects of "pre-workout" drinks on resistance training performance. Undergraduate Research Fellowship. University of Nebraska Kearney. Fall 2013 - Spring 2014.

Bridgette Schneekloth. Physical Activity while engaging in a Zumba dance class or Microsoft Kinect Zumba. Summer Student Research Program. University of Nebraska Kearney. Summer 2013.

Bridgette Schneekloth. Physical Activity while engaging in Microsoft Kinect Track & Field running vs. free running on an indoor track. Undergraduate Research Fellowship. University of Nebraska Kearney. Fall 2012 - Spring 2014.

Adam Kahle. Evaluating changes in running mechanics with "barefoot" footwear. Summer Student Research Program. University of Nebraska Kearney. Summer 2012

Michelle Jarvi. Quantifying paintball as a form of physical activity in Boys. Undergraduate Research Fellowship. University of Nebraska Kearney. Fall 2011 - Spring 2012.

Benjamin Lentz, Krista Scheer, & Sarah Siebrandt. Wii, Kinect, and Move for Physical Activity: Analysis of Energy Expenditure, Heart Rate, and Ventilation. Undergraduate Research Fellowship. University of Nebraska Kearney. Fall 2010 - Spring 2012.

Katlyn Heiserman. Comparison of EMG activity in the rectus abdominis and rectus femoris during supine un-weighted abdominal crunch exercise and a seated abdominal crunch exercise weight machine. Summer Student Research Program. University of Nebraska Kearney. Summer 2010

Janae Nienhueser. Effects of Energy drink on resting and submaximal exercise metabolism in college age men. Summer Student Research Program. University of Nebraska Kearney. Summer 2009

Jessica McWha. Metabolic changes while playing active video gaming against a human and computer opponent. Summer Student Research Program and Undergraduate Research Fellowship. University of Nebraska Kearney. Summer 2008 – Spring 2009

Sarah Horst. Changes in blood lactate and salivary cortisol concentrations while "exergaming" against a human or computer opponent. Summer Student Research Program. University of Nebraska Kearney. Summer 2008

Craig Carstensen. Differences in the Physiological Response to Treadmill versus Freely Paced Walking. Summer Student Research Program. University of Nebraska Kearney. Summer 2006

Alvah Stahlnecker Acute effects of a weight loss supplement on resting metabolic rate and anaerobic exercise performance. Summer Student Research Program. University of Nebraska Kearney. Summer 2005

Allison Swendener. Effects of exercise combined with a low carbohydrate diet on health. Summer Student Research Program. University of Nebraska Kearney. Summer 2005

Kamilah Whipple. A measurement of the physical activity and fitness of undergraduate Georgia Southern University students. Ronald E. McNair Post-Baccalaureate Achievement Program. Georgia Southern University. Summer 2004.

Lindsey Eck. Preliminary Analysis of Physical Fitness Levels in Kinesiology Students. Independent undergraduate research project. Georgia Southern University. Summer 2004.

Description of Graduate Courses Taught

PE 870: Advanced Exercise Physiology Course presumes a student has had a basic course in exercise physiology. The content of cardiorespiratory fitness, body composition, muscular strength/flexibility, body fluids and metabolism is presented beyond the introductory level. (University of Nebraska at Kearney)

PE 866P: Nutrition for Health and Sport. (Dual listed/taught with PE 469) Metabolism and metabolic regulation, the influence of dietary practices on health and human performance, and mechanisms and consequences of weight loss and gain.. (University of Nebraska Kearney)

PE 861P: Physiology of Exercise. (Dual listed/taught with PE 461) Physiological processes of body as pertain to physical activity. How trained and untrained individuals differ, and importance of training. (University of Nebraska at Kearney)

TE 800: Education Research. This introductory web-based course in educational research focuses on evaluating and interpreting educational research and applying its findings to educational practice. (University of Nebraska at Kearney)

KINS 7230: Exercise Physiology. Focuses on the study of the effects of exercise on the physiological functions of the human organism with emphasis on theoretical orientations. (Georgia Southern University)

KINS 7231: Laboratory Techniques in Exercise Physiology. Acquaints the student with the use of typical laboratory equipment used in exercise physiology. (Georgia Southern University)

KINS 7238: Human Performance and Nutrition. Examines the interaction between nutrition and physical activity, including exercise and athletic performance. (Georgia Southern University)

KINS 7431: Applied Sport Physiology. Focuses on the study of exercise physiology principles applied to developing training and conditioning programs for enhancing health related fitness and performance (Georgia Southern University)

KINS 7899: Directed Independent Study. Provides the student with an opportunity to investigate an area of interest under the direction of faculty mentor (Georgia Southern University)

EXSP 551: Advanced Exercise Physiology 2. Analysis of factors affecting work capacity and performance. Human energy metabolism concepts and measurement. (Iowa State University)

Description of Undergraduate Courses Taught

PE 498: Special Topics. (University of Nebraska at Kearney)

PE 475: Research Methods in Exercise Science. This course is designed to introduce advanced undergraduate students to the processes of research in the field of Exercise Science including the processes of finding, reading and understanding Exercise Science research; data collection; data analysis; and data interpretation. (University of Nebraska at Kearney)

PE 469: Sports Nutrition. Metabolism and metabolic regulation, the influence of dietary practices on human performance. (University of Nebraska at Kearney)

PE 461: Physiology of Exercise. Physiological processes of body as pertain to physical activity. How trained and untrained individuals differ, and importance of training. (University of Nebraska at Kearney)

PE 388: General Studies Capstone - The Living Dead in Fact & Fiction. The Living Dead, such as Zombies and Vampires, are pervasive in fictional literature, television, and movies. During this course, novels, television episodes, and movies will be used to identify disease symptoms displayed by the living dead, and these symptoms will then be evaluated regarding what type of medical condition might cause the symptoms.

PE 310: Introduction to Exercise Physiology. Provides a foundation of scientific basis for understanding the body's anatomical structures and physiologic responses to acute exercise, as well as its adaptations to chronic exercise. (University of Nebraska at Kearney)

PE 107. This course is designed to introduce students to the field of Exercise Science as an area of academic study and as a professional career. Students majoring in Exercise Science should take this course in their first year. (University of Nebraska at Kearney)

KINS 4231: Fitness Evaluation and Exercise Prescription. Provides the student with an in-depth study of fitness appraisal and exercise prescription and the development, interpretation, implementation and management of fitness programs (with laboratory). (Georgia Southern University)

KINS 3133: Physiological Aspects of Exercise. Provides an in-depth perspective of physiological and biochemical responses of the human body when subjected to exercise (with laboratory). (Georgia Southern University)

GSU 1210: University Orientation 1. Designed to help first year students understand the purpose of a college education, learn about college requirements, explore values and interests, learn to make decisions and realistic choices, explore career objectives and programs of study, and establish supportive relationships with faculty and staff. Required of all new students during their first semester. (Georgia Southern University)

EX SP 462: Medical Aspect of Exercise. The role of exercise in preventive medicine. Impact of exercise on various diseases, and the effect of various medical conditions on the ability to participate in vigorous exercise and competitive sports. Principles of exercise testing and prescription for individuals with these conditions. Environmental and nutritional aspects of exercise. (Iowa State University)

EX SP 458: Principles of Exercise Testing and Prescription. Physiological principles of physical fitness; design and administration of fitness programs; testing, evaluation, and prescription; cardiac risk factor modification. (Iowa State University)

EX SP 455 (Renumbered as EX SP 358 for Fall 2001). Physiology of Exercise. Physiological basis of human performance; effects of physical activity on body functions (with laboratory). (Iowa State University)

EX SP 355: Biomechanics (Laboratory). Mechanical basis of human performance; application of mechanical principles to exercise, sport and other physical activities. (Iowa State University)

EX SP 258: Physical Fitness and Conditioning. Development of personal fitness using a variety of conditioning and exercise techniques such as aerobics, weight training, and aquatic fitness. Introduction to acute and chronic responses to exercise, and the role of exercise in health promotion and weight management. (Iowa State University)

EX SP 236: Fundamentals of Archery, Badminton, Bowling (Archery Segment). (Iowa State University)

EX SP 119: Archery 1. (Iowa State University)

EX SP 220: Physical Fitness and Conditioning. Development of personal fitness using a variety of conditioning and exercise techniques such as aerobics, weight training, and aquatic fitness. Introduction to acute and chronic responses to exercise, and the role of exercise in health promotion and weight management. (Des Moines Area Community College)

PE 157: Introduction to Athletic training. Introduction to methods of prevention and immediate care of athletic injuries. Basic information concerning health supervision of athletes, and some basic wrapping and strapping techniques for common injuries. (Des Moines Area Community College)

PE 144: Introduction to Physical Education. History and development of physical education as an academic discipline. Principles and current practices of teaching physical education. (Des Moines Area Community College)

PHYSL 130: Human Physiology. Principles of the regulation and maintenance of human physiology. (Utah State University; Volunteer Undergraduate TA)

PHYSL 103 Human Anatomy. Introduction to the structure and location of bones, muscles, and organs in the human body. (Utah State University; Volunteer Undergraduate TA)

Service

Service to the Profession

Associate Editor, Asian Journal of Sports Medicine (2019-).

Director, North American Chapter, International Physical Activity Projects (IPAP) (2009-)

Fellow, American College of Sports Medicine (2008-_)

National Research Foundation (South Africa) peer evaluator for grant applicants

National Research Foundation (South Africa) evaluator of applications for funding in Thuthuka Programme

External Evaluator for Master's Theses and Doctoral Dissertations, University of Johannesburg, Johannesburg South Africa.

Grant proposal reviewer for NASPE/ING Run for Something Better School Awards Program.

Session Chair. Special Event. Undergraduate Research Experiences in Exercise Science. ACSM Annual Meeting, 2010

Session Chair. 2nd Annual Education Research Exchange. Iowa State University Education Research Exchange, 2001

Current Service at the University of Nebraska at Kearney

University Wide

Faculty Senate Parliamentarian (April 2019 – April 2022)

Faculty Senate Oversight Committee Chair (April 2019 – April 2022)

Faculty Senate Executive Committee (April 2019 – April 2022)

Faculty Senate, At Large representative (Fall 2018-)

University Student Conduct Appeals Board (Fall 2019 - May 2020)

General Studies Council (fall 2013-)

University Safety Committee (Fall 2018 -)

University Student Travel Policy Committee (Fall 2019-)

University Retention Council (Fall 2019 -)

External Evaluator, Promotion Committee, Department of Social Work & Criminal Justice (Fall 2019-)

College of Education Dean Search Committee Member (Fall 2019 -)

College of Education

College of Education Promotion and Tenure Committee, Chair (Fall 2012 – present) Member (fall 2008 – spring 2012)

Department of Kinesiology and Sport Sciences

Kinesiology Lecturer Search Committee Member (Fall 2019 -)

Nebraska Kids Fitness and Nutrition Day, volunteer educator and student coordinator. (fall 2005-present)

Academic Advisor for Undergraduate exercise Science Students (Fall 2005 - present)

Previous Service at the University of Nebraska at Kearney

Recreation Faculty Search Committee Member (Spring 2019)

University Student Conduct Board (Fall 2016- May 2017, Fall 2018 – May 2019)

Faculty Senate Athletic Committee (Fall 2018-May 2019)

External Evaluator, Promotion & Tenure, Department of Social Work & Criminal Justice (Fall 2018)

External Evaluator, Faculty Annual Performance Reviews, Department of Social Work & Criminal Justice (Spring 2018)

University Graduate Council. (Fall 2014 – spring 2017)

University Graduate Council Standing Committee I: Policy & Planning Committee (fall 2014 – spring 2017)

Faculty Senate (April 2012- April 2016)

Faculty Senate Executive Council, (April 2014 – April 2016)

Faculty Senate representative to the Oversight Committee (September 2014 – April 2016)

Faculty Senate representative to the Grievance Committee (September 2014 – April 2016)

Faculty Senate representative to the Professional Conduct committee (September 2013 - April 2016)

Youth Agility Speed & Quickness program director (2011-2015)

Faculty Senate ad-hoc committee on best practices in peer evaluation (2013-2014)

Director of General Studies search committee, committee member (2013-2014)

Director of the Office of Sponsored Programs search committee member (2012-2013; 2013-2014)

College peer mentor for implementing Critical Thinking in the classroom (2013-2014)

Chair, Ad-hoc committee for the evaluation of a new Student Evaluation of Instruction survey (2012-2014 academic years)

Ad-hoc committee to enhance communication effectiveness within department faculty and staff (2013-2014)

Exercise Science faculty search (2012-2013)

Undergraduate Research and Creative Activity program review team (2011-2012)

Institutional Review Board for the protection of Human Research Subjects. (Service period 2006 - 2011)

Undergraduate Research Committee (Service fall 2008 – spring 2011)

University Graduate Council. (Service period 2006 - 2010)

Homecoming Hustle (HPERLS Fun Run) Race Director and Coordinator (Service period beginning Fall 2007 – fall 2009)

Ad-hoc Committee on Enhancing Enrollment and Course Offerings in PE 110 Dept. of HPERLS (Service period beginning fall 2006)

Graduate Council Standing Committee 1: Policy and Planning Committee. (Service period beginning fall 2006; Chair in 2007 – 2008 and 2009-2010)

General Studies Roundtable 2 (spring 2006-spring 2007)

Academic Affairs Committee on Teaching Continuity (Service period beginning fall 2006)

Health Science Program Assistant Director Search Committee, University of Nebraska at Kearney. (Service period summer 2006)

Graduate Program Chair, HPERLS Department, University of Nebraska at Kearney (Service period beginning summer 2006 - 2010)

Graduate Dean Search Committee. University of Nebraska at Kearney (Service period 2005 – 2006 academic year)

Assistant HPERLS Department Graduate Coordinator. (Service period 2005 – 2006 academic year)

University of Nebraska at Kearney Centennial Run committee. (Service period fall 2005)

Senior College of Central Nebraska, Fit after 50 course coordinator. (Service period 2005 – 2006 academic year)

Health Science Program Assistant Advisor Search Committee. (Service period summer 2005)

HPERLS Furniture Committee (Service period spring 2005)

Academic Advisor for Undergraduate exercise Science Students (Service period Beginning Fall 2005 academic year; ongoing)

Other Prior University Service

Institutional Review Board, Georgia Southern University (2003- 2004)

GSU Exercise Science undergraduate student advisor (2002 – 2004)

GSU Jiann-Ping Hsu School of Public Health extramural funding task force (2003-2004)

GSU Jiann-Ping Hsu School of Public Health Curriculum Committee (2003-2004)

GSU Jiann-Ping Hsu School of Public Health Assistant Graduate program director (2003-2004)

GSU Jiann-Ping Hsu School of Public Health Laboratory Director's Committee (2002-2004)

GSU Jiann-Ping Hsu School of Public Health Exercise Science Graduate program coordinator (2003-2004)

GSU Recreation and Athletic Center advisor to the personal training program (2003-2004)

Institutional Biosafety Committee, Georgia Southern University (2003-2004)

Kinesiology Cluster Area, Georgia Southern University, Jiann-Ping Hsu School of Public Health (2002-2004)

Biostatistics Faculty Search Committee. Georgia Southern University, Jiann-Ping Hsu School of Public Health (2002-2003, 2003-2004)

Computer Advisory Committee, Iowa State University, University-Wide, College of Education, and Dept. of Health and Human Performance (2000-2002)

Computer Fee Allocation Committee, Iowa State University (2000-2001)

Dept. of Health and Human Performance Graduate Student Association (Founding Officer and 1st President; 2001-2002)

Sport Management Faculty Search Committee, Iowa State University Dept. of Health and Human Performance (2001-2002)

Previous Community Involvement

Race Director, Central Nebraska Susan G. Komen Race for the Cure (2011, 2012, 2013 events)

Webelos Den Leader, Boy Scouts of America Pack 132, Kearney, NE. Chartered to the Church of Jesus Christ of Latter Day Saints

Scoutmaster, Boy Scouts of America Troop 132, Kearney, NE. Chartered to the Church of Jesus Christ of Latter Day Saints

Tiger Den Coach, Boy Scouts of America Pack 135, Kearney, NE. Chartered to Faith United Methodist Church.

Personal Fitness Merit Badge Counselor. Boy Scouts of America, Overland Trails Council Covered wagon District.

Certifications

American College of Sports Medicine: ACSM Certified Exercise Physiologist (05/21/1998 - 12/31/2021)

USA Track and Field: Level One Coach

American Red Cross: Community First Aid and CPR

Funding

Research Funding

Brown GA, Bice MR, Abbey BM. Shaw I, Shaw BS. Effects of aerobic exercise, resistance exercise, and combined aerobic & resistance exercise on food choices and endocrine signals of satiety in middle aged adults. Submitted 6/26/2017 to National Institutes of Health [PA16-200] - Academic Research Enhancement Award (Parent R15) (Application #1R15DK117436-01). Total Amount Requested: $367,708. (Resubmission of revised proposal; Pending Review.)

Brown GA, Bice MR, Abbey BM. Shaw I, Shaw BS. Effects of aerobic exercise, resistance exercise, and combined aerobic & resistance exercise on food choices and endocrine signals of satiety in middle aged adults. Submitted 6/26/2017 to National Institutes of Health [PA16-200] - Academic Research Enhancement Award (Parent R15) (Application #1R15DK117436-01). Total Amount Requested: $351,708. Pending Review.

Brown GA, Bice MR, Adkins MM, Hollman A, Bickford S, Bickford N, Ranglack D. HEAT it up (Health, Exercise, Aquaponics, Technology) summer camps to grow future health professionals in Rural Nebraska. Submitted 5/25/2017 to National Institutes of Health [PAR17-183] - NICHD Research Education Programs (R25) (Application # 1R25 HD094673-01) Total Amount Requested: $777,006. Pending Review.

Brown GA, Bice MR, Adkins MM, Hollman A, Bickford S, Bickford N, Ranglack D. Teaching Health, Exercise, Technology, & Aquaponics (THETA) Day Camps to Grow Future Health Professionals. University of Nebraska Rural Futures Institutes (RFI) $20,000 – Funded (July 1, 2017 – June 30, 2019)

Brown GA, Bice MR, Adkins MM, Hollman A, Bickford S, Bickford N, Ranglack D. Teaching Health, Exercise, Technology, & Aquaponics (THETA) Day Camps to Grow Future Health Professionals. University of Nebraska Rural Futures Institutes (RFI) and McCook Economic Development Council $11,400 – Funded (May 1, 2017 – August 30, 2017)

Brown GA, Abbey BM, Bice MR. **"**Is milk an effective rehydration beverage during repeated days of dehydrating exercise?" to the Dairy Research Institute® (DRI) $125,560 – Not funded.

Brown GA & Steele J. "Biochemistry Laboratory Experiences for Exercise Science Students" to the Kelly Fund, University of Nebraska. $23,947. Funded. August 2014- June 2016

Brown GA. "Horizon After School Quickness Program" to Blue Cross & Blue Shield of Nebraska for a Community Wellness grant. $14,106. Not funded

Brown GA. "Effects of chocolate milk taken immediately post exercise on the adaptations to strength training in men" to the Dairy Research Institute® (DRI) $123,192 – not funded.

Brown GA., Heelan KA, Bartee RT, & Maughan S. "Active Video Games as an Alternative to Traditional Group Exercise Classes" to the Robert Wood Johnson Health Games Research program. $297,201 – not funded

Brown GA., Nylander B, Heelan KA. Energy Expenditure for Active Video Game Systems: Dance Dance Revolution and Nintendo Wii. University of Nebraska at Kearney Research Services Council. $3,432. Funded

Brown G.A. Effects of green tea extract on fasting plasma insulin, glucose, leptin, and PYY concentrations in humans. University of Nebraska at Kearney Research Services Council. $3,822. Funded

Brown G.A. Dose response relationship between resistance exercise and changes in the hormonal regulation of blood glucose homeostasis. American Diabetes Association Junior faculty Award. $443,293. Not Funded.

Brown G.A., and K. Heelan. Health benefits of green tea extract in women. NIH NCCAM Exploratory/Developmental Grant for Clinical Studies (R21), PAR-03-153. $485,163. Not Funded.

Brown, G.A. Changes In Biomarkers Of Satiety, Aerobic Fitness, And Body Composition While On A Low Fat Or Low Carbohydrate Diet. University of Nebraska at Kearney Research Services Council. $3,750. Funded

Lynott, F., **Brown, G.A**., and K. Heelan. Health and Fitness of HPERLS Students. University of Nebraska at Kearney Research Services Council. $4,000. Funded

Brown G.A., K. Heelan and D.S. King. Pharmacokinetics & Efficacy of Sublingual Androstenediol for Treating Andropause. NIH NCCAM Exploratory/Developmental Grant for Clinical Studies (R21), PAR-03-153. $477,000. Not Funded.

Maughan S.L., D.P.Snider, and **G.A. Brown,** Physical Health and Social Factors Influencing Educational Success Among Hispanic Immigrant Children, University of Nebraska at Kearney Research Services Council. $4,214.60. Funded

McFarland S.P. and **G.A. Brown,** Effects of Exercise Duration on Glucose Tolerance In Mildly Overweight Men, University of Nebraska at Kearney Research Services Council. $750. Funded

Brown, G.A. Effects of Exercise Duration on Insulin Sensitivity In Mildly Overweight Men, University of Nebraska at Kearney Research Services Council. $2,000. Funded

McFarland S.P. and **G.A.Brown,** Effects of Exercise Duration on Glucose Tolerance In Mildly Overweight Men, Gatorade Sports Sciences Institute. $1,500. Not Funded

Brown, G.A. Effects of Exercise Duration on Glucose Tolerance and Insulin Sensitivity in Mildly Overweight Men. Life fitness Academy. $5,000. not funded

Brown, G.A. American College of Sports Medicine Foundation Grant. Endocrinology of weight lifting & androgen supplementation, $10,000. Not Funded.

Brown, G.A. and J.L. McMillan. Experimental and Applied Sciences. Effects of Green Tea Extract on Insulin Sensitivity and Adaptations to Exercise. $71,075. Not Funded.

Brown, G.A. American College of Sports Medicine Foundation Grant. Endocrinology of weight training & androgen supplementation, $10,000. Not Funded.

Brown, G.A. and J. Drouin. Georgia Southern University Faculty Research Grant. Effects of Resistance Training on the Hormonal response to Sublingual Androstenediol Intake. $5,000. Funded

King D.S. and **G.A. Brown.** *World Anti Doping Agency.* Effects of Testosterone Precursors on the Muscular and Hormonal Response to Resistance Training in Men. $464,634. Not Funded.

Brown, G.A. *American College of Sports Medicin*e Foundation Grant. Effect of Raisin Ingestion on Substrate Use During Exercise. $5,000. Not Funded.

King D.S. and **G.A. Brown.** *California Raisin Marketing Board.* The Glycemic Index Of Raisins Fed To Normal People And Non-Insulin Dependent Diabetics. $110,869. Not Funded.

King D.S. and **G.A. Brown.** *California Raisin Marketing Board.* The Effects Of Raisin Ingestion On Substrate Utilization and Endurance Exercise Performance In Trained Cyclists. $ 84,258. Not Funded.

Brown, G.A., E.R. Martini, and B.S. Roberts. Effect of Androstenediol on Serum Sex Hormone Concentrations. Iowa State University Professional Advancement Grant. Graduate Student Senate and Iowa State University Dept. of Health and Human Performance. $700. Funded

Instructional Development Funding

Brown G.A. and K.A. Heelan. University of Nebraska at Kearney. Proposal for the purchase of upgraded resistance exercise equipment in the Human Performance Laboratory. $21,100. Funded.

Brown G.A. and K.A. Heelan. University of Nebraska at Kearney. Proposal for the purchase of a new metabolic cart for the Human Performance Laboratory. $24,560. Funded

Brown, G.A. Georgia Southern University, Center for Excellence in Teaching Instructional Development Grant. Proposal for purchase of heart rate monitors, manual sphygmomanometers, and automated sphygmomanometers. $2,820. Funded.

Brown, G.A. Georgia Southern University, Center for Excellence in Teaching Innovative Teaching Strategies Retreat. Provides $2,000 in instructional technology funds to the participant. Funded.

Brown, G.A. Georgia Southern University, Center for Excellence in Teaching Travel Grant. $750. Funded.

Brown, G.A. Georgia Southern University student technology fee proposal. Proposal for purchase of Molecular Devices SpectraMax 250 plate reader. $17,000. Funded

Brown, G.A. Georgia Southern University student technology fee proposal. Proposal for purchase of Lode Excalibur Sport Bicycle Ergometer and Physiodyne Max 2 Metabolic Cart. $29,577. Funded

Brown, G.A. Georgia Southern University student technology fee proposal. Proposal for purchase of Packard Cobra 2 Automated Gamma Counter. $14,000. Not funded

References

Dr. Ina Shaw
+27 12 671 8810
ina.shaw@momentum.co.za
MMI Client Engagement Solutions
Visiting Professor - University of Johannesburg
Adjunct Professor - University of Venda
President: International Physical Activity Projects (IPAP)

Dr. Kenya Taylor
(308) 865-8843
taylorks@unk.edu
Dean, Graduate Studies & Research
University of Nebraska Kearney

Dr. Matthew R. Bice
(308) 865-8052
bicemr@unk.edu
Assistant Professor, Dept of Kinesiology & Sports Sciences
University of Nebraska Kearney

Exhibit B

IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF WEST VIRGINIA
CHARLESTON DIVISION

B.P.J., by her next friend and mother, HEATHER JACKSON,

Plaintiff,

vs.

WEST VIRGINIA STATE BOARD OF EDUCATION; HARRISON COUNTY BOARD OF EDUCATION; WEST VIRGINIA SECONDARY SCHOOLS ACTIVITIES COMMISSION; W. CLAYTON BURCH, in his official capacity as State Superintendent, DORA STUTLER, in her official capacity as the Harrison County Superintendent, and the STATE OF WEST VIRGINIA,

Defendants,

and

LAINEY ARMISTEAD,

Defendant-Intervenor.

Case No. 2:21-cv-00316

Hon. Joseph R. Goodwin

DECLARATION OF GREGORY A. BROWN, PH.D., FACSM

I, Dr. Gregory A. Brown, pursuant to 28 U.S. Code § 1746, declare under penalty of perjury under the laws of the United States of America that the facts contained in my Expert Declaration of Gregory A. Brown, Ph.D., FACSM in the Case of B.P.J. v. West Virginia State Board of Education, attached hereto, are true and correct to the best of my knowledge and belief, and that the opinions expressed therein represent my own expert opinions.

Executed on February 23, 2022.

Gregory A. Brown

Expert Report of

Gregory A Brown, Ph.D. FACSM

In the case of B.P.J. vs. West Virginia State Board of Education.

Table of Contents

Personal Qualifications and Disclosure

I serve as Professor of Exercise Science in the Department of Kinesiology and Sport Sciences at the University of Nebraska Kearney, where I teach classes in Exercise Physiology among other topics. I am also the Director of the General Studies program. I have served as a tenured (and nontenured) professor at universities since 2002.

In August 2002, I received a Doctor of Philosophy degree from Iowa State University, where I majored in Health and Human Performance, with an emphasis in the Biological Bases of Physical Activity. In May 1999, I received a Master of Science degree from Iowa State University, where I majored in Exercise and Sport Science, with an emphasis in Exercise Physiology.

I have received many awards over the years, including the Mortar Board Faculty Excellence Honors Award, College of Education Outstanding Scholarship / Research Award, and the College of Education Award for Faculty Mentoring of Undergraduate Student Research. I have authored more than 40 refereed publications and more than 50 refereed presentations in the field of Exercise Science. I have authored chapters for multiple books in the field of Exercise Science. And I have served as a peer reviewer for over 25 professional journals, including *The American Journal of Physiology*, the *International Journal of Exercise Science*, the *Journal of Strength and Conditioning Research*, and *The Journal of Applied Physiology*.

My areas of research have included the endocrine response to testosterone prohormone supplements in men and women, the effects of testosterone prohormone supplements on health and the adaptations to strength training in men, the effects of energy drinks on the physiological response to exercise, and assessment of various athletic training modes in males and females. Articles that I have published that are closely related to topics that I discuss in this white paper include:

- Studies of the effect of ingestion of a testosterone precursor on circulating testosterone levels in young men. Douglas S. King, Rick L. Sharp, Matthew D. Vukovich, Gregory A. Brown, et al., *Effect of Oral Androstenedione on Serum Testosterone and Adaptations to Resistance Training in Young Men: A Randomized Controlled Trial*, JAMA 281: 2020-2028 (1999); G. A. Brown, M. A. Vukovich, et al., *Effects of Anabolic Precursors on Serum Testosterone Concentrations and Adaptations to Resistance Training in Young Men*, INT J SPORT NUTR EXERC METAB 10: 340-359 (2000).

- A study of the effect of ingestion of that same testosterone precursor on circulating testosterone levels in young women. G. A. Brown, J. C. Dewey, et

al., *Changes in Serum Testosterone and Estradiol Concentrations Following Acute Androstenedione Ingestion in Young Women*, HORM METAB RES 36: 62-66 (2004.)

- A study finding (among other things) that body height, body mass, vertical jump height, maximal oxygen consumption, and leg press maximal strength were higher in a group of physically active men than comparably active women, while the women had higher percent body fat. G. A. Brown, Michael W. Ray, et al., *Oxygen Consumption, Heart Rate, and Blood Lactate Responses to an Acute Bout of Plyometric Depth Jumps in College-Aged Men And Women*, J. STRENGTH COND RES 24: 2475-2482 (2010).

- A study finding (among other things) that height, body mass, and maximal oxygen consumption were higher in a group of male NCAA Division 2 distance runners, while women NCAA Division 2 distance runners had higher percent body fat. Furthermore, these male athletes had a faster mean competitive running speed (~3.44 min/km) than women (~3.88 min/km), even though the men ran 10 km while the women ran 6 km. Katherine Semin, Alvah C. Stahlnecker, Kate A. Heelan, G. A. Brown, et al, *Discrepancy Between Training, Competition and Laboratory Measures of Maximum Heart Rate in NCAA Division 2 Distance Runners*, JOURNAL OF SPORTS SCIENCE AND MEDICINE 7: 455-460 (2008).

- A presentation at the 2021 American Physiological Society New Trends in Sex and Gender Medicine Conference entitled "Transwomen Competing in Women's Sports: What We Know and What We Don't". I have also authored an August 2021 entry for the American Physiological Society Physiology Educators Community of Practice Blog (PECOP Blog) titled "The Olympics, Sex, and Gender in the Physiology Classroom."

A list of my published scholarly work for the past 10 years appears as an Appendix.

Purpose of this Declaration

I have been asked by counsel for Defendant State of West Virginia and Intervenor Defendant Lainey Armistead in the matter of *B.P.J. by her next friend and mother Heather Jackson, v. State of West Virginia State Board of Education, et al.* to offer my opinions about the following: (a) whether males have inherent advantages in athletic performance over females, and if so the scale and physiological basis of those advantages, to the extent currently understood by science and (b) whether the sex-based performance advantage enjoyed by males is eliminated if feminizing hormones are administered to male athletes who identify as transgender (and in the case of prepubertal children, whether puberty blockers eliminate the advantage). In this declaration, when I use the terms "boy" or "male," I am referring to biological males based on the individual's reproductive biology and genetics as determined at birth. Similarly, when I use the terms "girl" or "female," I am referring to biological females based on the individual's reproductive biology and genetics as determined at birth. When I use the term transgender, I am referring to persons who are males or females, but who identify as a member of the opposite sex.

I have previously provided expert information in cases similar to this one in the form of a written declaration and a deposition in the case of *Soule vs. CIAC* in the state of Connecticut, and in the form of a written declaration in the case of *Hecox vs. Little* in the state of Idaho. I have not previously testified as an expert in any trials.

The opinions I express in this declaration are my own, and do not necessarily reflect the opinions of my employer, the University of Nebraska.

I have been compensated for my time serving as an expert in this case at the rate of $150 per hour. My compensation does not depend on the outcome in the case.

Overview

In this declaration, I explore three important questions relevant to current discussions and policy decisions concerning inclusion of transgender individuals in women's athletic competitions. Based on my professional familiarity with exercise physiology and my review of the currently available science, including that contained in the many academic sources I cite in this report, I set out and explain three basic conclusions:

- At the level of (a) elite, (b) collegiate, (c) scholastic, and (d) recreational competition, men, adolescent boys, or male children, have an advantage over equally aged, gifted, and trained women, adolescent girls, or female children in almost all athletic events;

- Biological male physiology is the basis for the performance advantage that men, adolescent boys, or male children have over women, adolescent girls, or female children in almost all athletic events; and

- The administration of androgen inhibitors and cross-sex hormones to men or adolescent boys after the onset of male puberty does not eliminate the performance advantage that men and adolescent boys have over women and adolescent girls in almost all athletic events. Likewise, there is no published scientific evidence that the administration of puberty blockers to males before puberty eliminates the pre-existing athletic advantage that prepubertal males have over prepubertal females in almost all athletic events.

In short summary, men, adolescent boys, and prepubertal male children perform better in almost all sports than women, adolescent girls, and prepubertal female children because of their inherent physiological advantages. In general, men, adolescent boys, and prepubertal male children, can run faster, output more muscular power, jump higher, and possess greater muscular endurance than women, adolescent girls, and prepubertal female children. These advantages become greater during and after male puberty, but they exist before puberty.

Further, while after the onset of puberty males are on average taller and heavier than females, a male performance advantage over females has been measured in weightlifting competitions even between males and females matched for body mass.

Male advantages in measurements of body composition, tests of physical fitness, and athletic performance have also been shown in children before puberty. These advantages are magnified during puberty, triggered in large part by the higher testosterone concentrations in men, and adolescent boys, after the onset of

male puberty. Under the influence of these higher testosterone levels, adolescent boys and young men develop even more muscle mass, greater muscle strength, less body fat, higher bone mineral density, greater bone strength, higher hemoglobin concentrations, larger hearts and larger coronary blood vessels, and larger overall statures than women. In addition, maximal oxygen consumption (VO_2max), which correlates to ~30-40% of success in endurance sports, is higher in both elite and average men and boys than in comparable women and girls when measured in regard to absolute volume of oxygen consumed and when measured relative to body mass.

Although androgen deprivation (that is, testosterone suppression) may modestly decrease some physiological advantages that men and adolescent boys have over women and adolescent girls, it cannot fully or even largely eliminate those physiological advantages once an individual has passed through male puberty.

Evidence and Conclusions

I. The scientific reality of biological sex

1. The scientific starting point for the issues addressed in this report is the biological fact of dimorphic sex in the human species. It is now well recognized that dimorphic sex is so fundamental to human development that, as stated in a recent position paper issued by the Endocrine Society, it "must be considered in the design and analysis of human and animal research. . . . Sex is dichotomous, with sex determination in the fertilized zygote stemming from unequal expression of sex chromosomal genes." (Bhargava et al. 2021 at 220). As stated by Sax (2002 at 177), "More than 99.98% of humans are either male or female." All humans who do not suffer from some genetic or developmental disorder are unambiguously male or female.

2. Although sex and gender are used interchangeably in common conversation, government documents, and in the scientific literature, the American Psychological Association defines sex as "physical and biological traits" that "distinguish between males and females" whereas gender "implies the psychological, behavioral, social, and cultural aspects of being male or female (i.e., masculinity or femininity)" (https://dictionary.apa.org, accessed January 14, 2022). The concept that sex is an important biological factor determined at conception is a well-established scientific fact that is supported by statements from a number of respected organizations including, but not limited to, the Endocrine Society (Bhargava et al. 2021 at 220), the American Physiological Society (Shah 2014), the Institute of Medicine, and the National Institutes of Health (Miller 2014 at H781-82). Collectively, these and other organizations have stated that every cell has a sex

and every system in the body is influenced by sex. Indeed, "sex often influences gender, but gender cannot influence sex." (Bhargava 2021 at 228.)

3. To further explain: "The classical biological definition of the **2 sexes** is that females have ovaries and make larger female gametes (eggs), whereas males have testes and make smaller male gametes (sperm) … the definition can be extended to the ovaries and testes, and in this way the categories—female and male—can be applied also to individuals who have gonads but do not make gametes … sex is dichotomous because of the different roles of each sex in reproduction." (Bhargava 2021 at 221.) Furthermore, "sex determination begins with the inheritance of XX or XY chromosomes" (Bhargava 2021 at 221.) And, "Phenotypic sex differences develop in XX and XY embryos as soon as transcription begins. The categories of X and Y genes that are unequally represented or expressed in male and female mammalian zygotes … cause phenotypic sex differences" (Bhargava 2021 at 222.)

4. Although disorders of sexual development (DSDs) are sometimes confused with discussions of transgender individuals, the two are different phenomena. DSDs are disorders of physical development. Many DSDs are "associated with genetic mutations that are now well known to endocrinologists and geneticists." (Bhargava 2021 at 225) By contrast, a sense of transgender identity is usually not associated with any physical disorder, and "a clear biological causative underpinning of gender identity remains to be demonstrated." (Bhargava 2021 at 226.)

5. Further demonstrating the biological importance of sex, Gershoni and Pietrokovski (2017) detail the results of an evaluation of "18,670 out of 19,644 informative protein-coding genes in men versus women" and reported that "there are over 6500 protein-coding genes with significant S[ex]D[ifferential] E[xpression] in at least one tissue. Most of these genes have SDE in just one tissue, but about 650 have SDE in two or more tissues, 31 have SDE in more than five tissues, and 22 have SDE in nine or more tissues" (Gershoni 2017 at 2-3.) Some examples of tissues identified by these authors that have SDE genes include breast mammary tissue, skeletal muscle, skin, thyroid gland, pituitary gland, subcutaneous adipose, lung, and heart left ventricle. Based on these observations the authors state "As expected, Y-linked genes that are normally carried only by men show SDE in many tissues" (Gershoni 2017 at 3.) A stated by Heydari et al. (2022, at 1), "Y chromosome harbors male-specific genes, which either solely or in cooperation with their X-counterpart, and independent or in conjunction with sex hormones have a considerable impact on basic physiology and disease mechanisms in most or all tissues development."

6. In a review of 56 articles on the topic of sex-based differences in skeletal muscle, Haizlip et al., (2015) state that "More than 3,000 genes have been

identified as being differentially expressed between male and female skeletal muscle." (Haizlip 2015 at 30.) Furthermore, the authors state that "Overall, evidence to date suggests that skeletal muscle fiber-type composition is dependent on species, anatomical location/function, and sex" (Haizlip 2015 at 30.) The differences in genetic expression between males and females influence the skeletal muscle fiber composition (i.e. fast twitch and fast twitch sub-type and slow twitch), the skeletal muscle fiber size, the muscle contractile rate, and other aspects of muscle function that influence athletic performance. As the authors review the differences in skeletal muscle between males and females they conclude, "Additionally, all of the fibers measured in men have significantly larger cross-sectional areas (CSA) compared with women." (Haizlip 2015 at 31.) The authors also explore the effects of thyroid hormone, estrogen, and testosterone on gene expression and skeletal muscle function in males and females. One major conclusion by the authors is that "The complexity of skeletal muscle and the role of sex adding to that complexity cannot be overlooked." (Haizlip 2015 at 37.) The evaluation of SDE in protein coding genes helps illustrate that the differences between men and women are intrinsically part of the chromosomal and genetic makeup of humans which can influence many tissues that are inherent to the athletic competitive advantages of men compared to women.

II. Biological men, or adolescent boys, have large, well-documented performance advantages over women and adolescent girls in almost all athletic contests.

7. It should scarcely be necessary to invoke scientific experts to "prove" that men are on average larger, stronger, and faster than women. All of us, along with our siblings and our peers and perhaps our children, have passed through puberty, and we have watched that differentiation between the sexes occur. This is common human experience and knowledge.

8. Nevertheless, these differences have been extensively studied and measured. I cited many of these studies in the first paper on this topic that I prepared, which was submitted in litigation in January 2020. Since then, in light of current controversies, several authors have compiled valuable collections or reviews of data extensively documenting this objective fact about the human species, as manifest in almost all sports, each of which I have reviewed and found informative. These include Coleman (2020), Hilton & Lundberg (2021), World Rugby (2020), Harper (2021), Hamilton (2021), and a "Briefing Book" prepared by the Women's Sports Policy Working Group (2021). The important paper by Handelsman et al. (2018) also gathers scientific evidence of the systematic and large male athletic advantage.

9. These papers and many others document that men, adolescent boys, and prepubertal male children, substantially outperform comparably aged women,

adolescent girls and prepubertal female children, in competitions involving running speed, swimming speed, cycling speed, jumping height, jumping distance, and strength (to name a few, but not all, of the performance differences). As I discuss later, it is now clear that these performance advantages for men, adolescent boys, and prepubertal male children, are inherent to the biological differences between the sexes.

10. In fact, I am not aware of any scientific evidence today that disproves that after puberty men possess large advantages in athletic performance over women–so large that they are generally insurmountable for comparably gifted and trained athletes at every level (i.e. (a) elite, (b) collegiate, (c) scholastic, and (d) recreational competition). And I am not aware of any scientific evidence today that disproves that these measured performance advantages are at least largely the result of physiological differences between men and women which have been measured and are reasonably well understood.

11. My use of the term "advantage" in this paper must not be read to imply any normative judgment. The adult female physique is simply different from the adult male physique. Obviously, it is optimized in important respects for the difficult task of childbearing. On average, women require far fewer calories for healthy survival. Evolutionary biologists can and do theorize about the survival value or "advantages" provided by these and other distinctive characteristics of the female physique, but I will leave that to the evolutionary biologists. I use "advantage" to refer merely to performance advantages in athletic competitions.

12. I find in the literature a widespread consensus that the large performance and physiological advantages possessed by males–rather than social considerations or considerations of identity–are precisely the *reason* that most athletic competitions are separated by sex, with women treated as a "protected class." To cite only a few statements accepting this as the justification:

- Handelsman et al. (2018) wrote, "Virtually all elite sports are segregated into male and female competitions. The main justification is to allow women a chance to win, as women have major disadvantages against men who are, on average, taller, stronger, and faster and have greater endurance due to their larger, stronger, muscles and bones as well as a higher circulating hemoglobin level." (803)

- Millard-Stafford et al. (2018) wrote "Current evidence suggests that women will not swim or run as fast as men in Olympic events, which speaks against eliminating sex segregation in these individual sports" (530) "Given the historical context (2% narrowing in swimming over 44 y), a reasonable assumption might be that no more than 2% of the

current performance gap could still potentially be attributed to sociocultural influences.", (533) and "Performance gaps between US men and women stabilized within less than a decade after federal legislation provided equal opportunities for female participation, but only modestly closed the overall gap in Olympic swimming by 2% (5% in running)." (533) Dr. Millard-Stafford, a full professor at Georgia Tech, holds a Ph.D. in Exercise Physiology and is a past President of the American College of Sports Medicine.

- In 2021, Hilton et al. wrote, "most sports have a female category the purpose of which is the protection of both fairness and, in some sports, safety/welfare of athletes who do not benefit from the physiological changes induced by male levels of testosterone from puberty onwards." (204)

- In 2020 the Swiss High Court ("Tribunal Fédéral") observed that "in most sports . . . women and men compete in two separate categories, because the latter possess natural advantages in terms of physiology."[1]

- The members of the Women's Sports Policy Working Group wrote that "If sports were not sex-segregated, female athletes would rarely be seen in finals or on victory podiums," and that "We have separate sex sport and eligibility criteria based on biological sex because this is the only way we can assure that female athletes have the same opportunities as male athletes not only to participate but to win in competitive sport. . . . If we did not separate athletes on the basis of biological sex–if we used any other physical criteria–we would never see females in finals or on podiums." (WSPWG Briefing Book 2021 at 5, 20.)

- In 2020, the World Rugby organization stated that "the women's category exists to ensure protection, safety and equality for those who do not benefit from the biological advantage created by these biological performance attributes." (World Rugby Transgender Women Guidelines 2020.)

- In 2021 Harper et al. stated "…the small decrease in strength in transwomen after 12–36 months of GAHT [Gender Affirming Hormone Therapy] suggests that transwomen likely retain a strength advantage

[1] "dans la plupart des sports . . . les femmes et les hommes concourent dans deux catégories séparées, ces derniers étant naturellement avantagés du point de vue physique." Tribunal Fédéral decision of August 25, 2020, Case 4A_248/2019, 4A_398/2019, at §9.8.3.3.

over cisgender women." (7) and "…observations in trained transgender individuals are consistent with the findings of the current review in untrained transgender individuals, whereby 30 months of GAHT may be sufficient to attenuate some, but not all, influencing factors associated with muscular endurance and performance." (8)

- Hamilton et al. (2021), in a consensus statement for the International Federation of Sports Medicine (FIMS) concluded that "Transwomen have the right to compete in sports. However, cisgender women have the right to compete in a protected category." (1409)

13. While the sources I mention above gather more extensive scientific evidence of this uncontroversial truth, I provide here a brief summary of representative facts concerning the male advantage in athletic performance.

A. Men are stronger.

14. Males exhibit greater strength throughout the body. Both Handelsman et al. (2018) and Hilton & Lundberg (2021) have gathered multiple literature references that document this fact in various muscle groups.

15. Men have in the neighborhood of 60%-100% greater **arm strength** than women. (Handelsman 2018 at 812.)[2] One study of elbow flexion strength (basically, bringing the fist up towards the shoulder) in a large sample of men and women found that men exhibited 109% greater isometric strength, and 89% higher strength in a single repetition. (Hilton 2021 at 204, summarizing Hubal (2005) at Table 2.)

16. **Grip strength** is often used as a useful proxy for strength more generally. In one study, men showed on average 57% greater grip strength than women. (Bohannon 2019.) A wider meta-analysis of multiple grip-strength studies not limited to athletic populations found that 18- and 19-year-old males exhibited in

[2] Handelsman expresses this as women having 50% to 60% of the "upper limb" strength of men. Handelsman cites Sale, *Neuromuscular function*, for this figure and the "lower limb" strength figure. Knox et al., *Transwomen in elite sport* (2018) are probably confusing the correct way to state percentages when they state that "differences lead to decreased trunk and lower body strength by 64% and 72% respectively, in women" (397): interpreted literally, this would imply that men have **almost 4x as much** lower body strength as do women.

the neighborhood of 2/3 greater grip strength than females. (Handelsman 2017 Figure 3, summarizing Silverman 2011 Table 1.)[3]

17. In an evaluation of maximal isometric handgrip strength in 1,654 healthy men, 533 healthy women aged 20-25 years and 60 "highly trained elite female athletes from sports known to require high hand-grip forces (judo, handball)," Leyk et al. (2007) observed that, "The results of female national elite athletes even indicate that the strength level attainable by extremely high training will rarely surpass the 50th percentile of untrained or not specifically trained men." (Leyk 2007 at 415.)

18. Men have in the neighborhood of 25%-60% greater **leg strength** than women. (Handelsman 2018 at 812.) In another measure, men exhibit 54% greater knee extension torque and this male leg strength advantage is consistent across the lifespan. (Neder 1999 at 120-121.)

19. When male and female Olympic weightlifters of the same body weight are compared, the top males lift weights between 30% and 40% greater than the females of the same body weight. But when top male and female performances are compared in powerlifting, without imposing any artificial limitations on bodyweight, the male record is 65% higher than the female record. (Hilton 2021 at 203.)

20. In another measure that combines many muscle groups as well as weight and speed, moderately trained males generated 162% greater punching power than females even though men do not possess this large an advantage in any single bio-mechanical variable. (Morris 2020.) This objective reality was subjectively summed up by women's mixed-martial arts fighter Tamikka Brents, who suffered significant facial injuries when she fought against a biological male who identified as female and fought under the name of Fallon Fox. Describing the experience, Brents said:

> "I've fought a lot of women and have never felt the strength that I felt in a fight as I did that night. I can't answer whether it's because she was born a man or not because I'm not a doctor. I can only say, I've never felt so overpowered ever in my life, and I am an abnormally strong female in my own right."[4]

---

[3] Citing Silverman, *The secular trend for grip strength in Canada and the United States*, J. Ports Sci. 29:599-606 (2011).

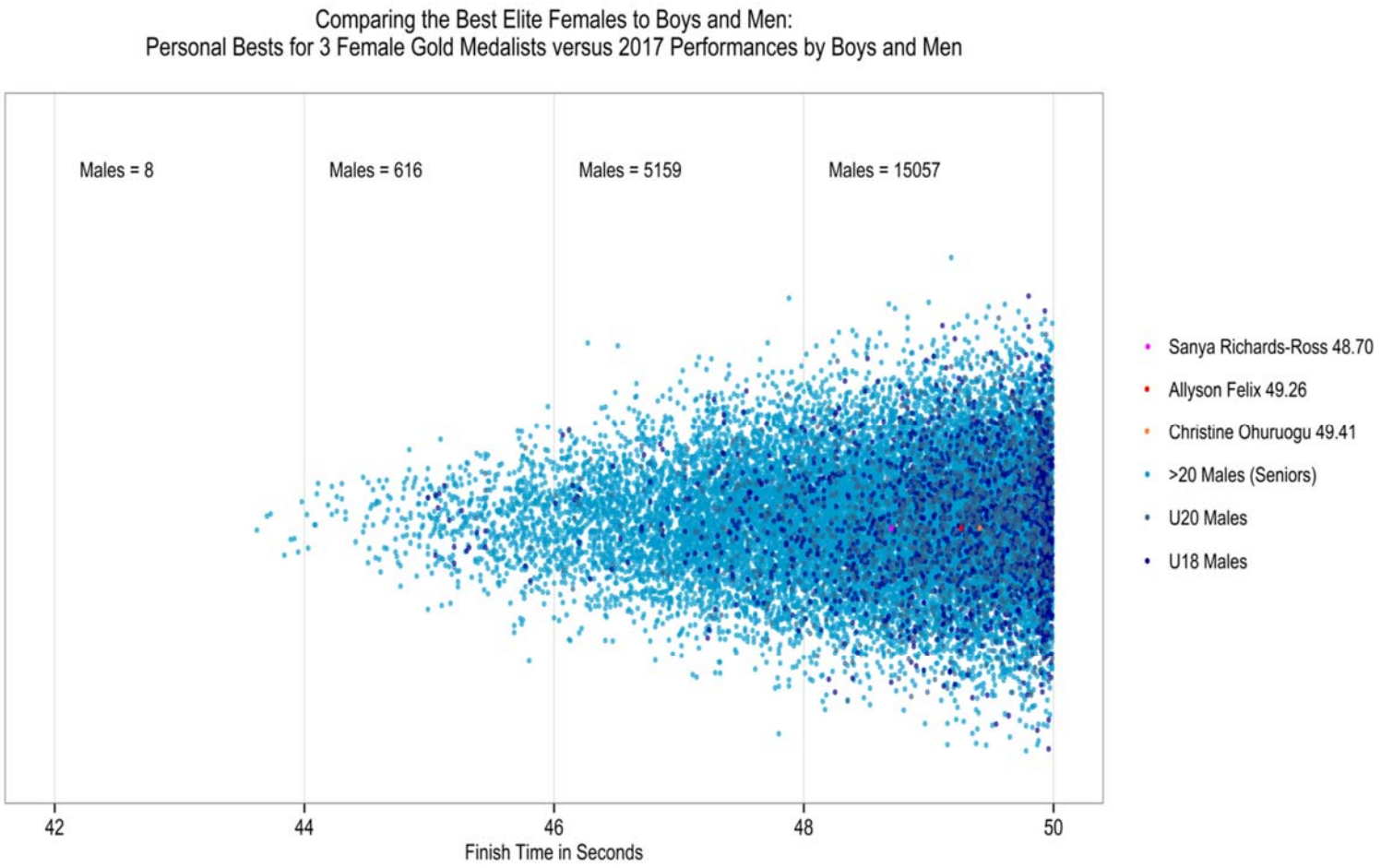
[4] http://whoatv.com/exclusive-fallon-foxs-latest-opponent-opens-up-to-whoatv/ (last accessed October 5, 2021).

B. Men run faster.

21. Many scholars have detailed the wide performance advantages enjoyed by men in running speed. One can come at this reality from a variety of angles.

22. Multiple authors report a male speed advantage in the neighborhood of 10%-13% in a variety of events, with a variety of study populations. Handelsman et al. 2018 at 813 and Handelsman 2017 at 70 both report a male advantage of about 10% by age 17. Thibault et al. 2010 at 217 similarly reported a stable 10% performance advantage across multiple events at the Olympic level. Tønnessen et al. (2015 at 1-2) surveyed the data and found a consistent male advantage of 10%-12% in running events after the completion of puberty. They document this for both short sprints and longer distances. One group of authors found that the male advantage increased dramatically in ultra-long-distance competition (Lepers & Knechtle 2013.)

23. A great deal of current interest has been focused on track events. It is worth noting that a recent analysis of publicly available sports federation and tournament records found that men enjoy the *least* advantage in running events, as compared to a range of other events and metrics, including jumping, pole vaulting, tennis serve speed, golf drives, baseball pitching speed, and weightlifting. (Hilton 2021 at 201-202.) Nevertheless, as any serious runner will recognize, the approximately 10% male advantage in running is an overwhelming difference. Dr. Hilton calculates that "approximately 10,000 males have personal best times that are faster than the current Olympic 100m female champion." (Hilton 2021 at 204.) Professors Doriane Coleman, Jeff Wald, Wickliffe Shreve, and Richard Clark dramatically illustrated this by compiling the data and creating the figure below (last accessed on February 10, 2022, at https://bit.ly/35yOyS4), which shows that the *lifetime best performances* of three female Olympic champions in the 400m event—including Team USA's Sanya Richards-Ross and Allyson Felix—would not match the performances of "literally thousands of boys and men, including thousands who would be considered second tier in the men's category" *just in 2017 alone*: (data were drawn from the International Association of Athletics Federations (IAAF) website which provides complete, worldwide results for individuals and events, including on an annual and an all-time basis).


Comparing the Best Elite Females to Boys and Men:
Personal Bests for 3 Female Gold Medalists versus 2017 Performances by Boys and Men
Males = 8
Males = 616
Males = 5159
Males = 15057
42
44
46
48
50
Finish Time in Seconds
Sanya Richards-Ross 48.70
Allyson Felix 49.26
Christine Ohuruogu 49.41
>20 Males (Seniors)
U20 Males
U18 Males

24. Professor Coleman and her colleague Wicklyffe Shreve also created the table below (last accessed on February 10, 2022, at https://bit.ly/37E1s2X), which "compares the number of men—males over 18—competing in events reported to the International Association of Athletics Federation whose results in each event in 2017 would have ranked them above the very best elite woman that year."

TABLE 2 – World's Best Woman v. Number of Men Outperforming			
Event	Best Women's Result	Best Men's Result	# of Men Outperforming
100 Meters	10.71	9.69	2,474
200 Meters	21.77	19.77	2,920
400 Meters	49.46	43.62	4,341
800 Meters	1:55.16*	1:43.10	3,992+
1500 Meters	3:56.14	3:28.80	3,216+
3000 Meters	8:23.14	7:28.73	1307+
5000 Meters	14:18.37	12:55.23	1,243
High Jump	2.06 meters	2.40 meters	777
Pole Vault	4.91 meters	6.00 meters	684
Long Jump	7.13 meters	8.65 meters	1,652
Triple Jump	14.96 meters	18.11 meters	969

25. The male advantage becomes insuperable well before the developmental changes of puberty are complete. Dr. Hilton documents that even "schoolboys"–defined as age 15 and under–have beaten the female world records in running, jumping, and throwing events. (Hilton 2021 at 204.)

26. Similarly, Coleman and Shreve created the table below (last accessed on February 10, 2022, at https://bit.ly/37E1s2X), which "compares the number of boys—males under the age of 18—whose results in each event in 2017 would rank them above the single very best elite [adult] woman that year:" data were drawn from the International Association of Athletics Federations (IAAF) website

TABLE 1 – World's Best Woman v. Under 18 Boys			
Event	Best Women's Result	Best Boys' Result	# of Boys Outperforming
100 Meters	10.71	10.15	124+
200 Meters	21.77	20.51	182
400 Meters	49.46	45.38	285
800 Meters	1:55.16*	1:46.3	201+
1500 Meters	3:56.14	3:37.43	101+
3000 Meters	8:23.14	7:38.90	30
5000 Meters	14:18.37	12:55.58	15
High Jump	2.06 meters	2.25 meters	28
Pole Vault	4.91 meters	5.31 meters	10
Long Jump	7.13 meters	7.88 meters	74
Triple Jump	14.96 meters	17.30 meters	47

27. In an analysis I have performed of running events (consisting of the 100 m, 200 m, 400 m, 800 m, 1500 m, 5000 m, and 10000 m) in the Division 1, Division 2, and Division 3 NCAA Outdoor track championships for the years of 2010-2019, the average performance across all events of the 1st place man was 14.1% faster than the 1st place woman, with the smallest difference being a 10.2% advantage for men in the Division 1 100 m race. The average 8th place man across all events (the last place to earn the title of All American) was 11.2% faster than 1st place woman, with the smallest difference being a 6.5% advantage for men in the Division 1 100 m race. (Brown et al. Unpublished observations, to be presented at the 2022 Annual Meeting of the American College of Sports Medicine.)

28. Athletic.net® is an internet-based resource providing "results, team, and event management tools to help coaches and athletes thrive." Among the resources available on Athletic.net are event records that can be searched by nationally or by state age group, school grade, and state. Higerd (2021) in an evaluation of high school track running performance records from five states(CA, FL, MN, NY, WA), over three years (2017 – 2019) observed that males were 14.38% faster than females in the 100M (at 99), 16.17% faster in the 200M (at 100), 17.62% faster in the 400M (at 102), 17.96% faster in the 800M (at 103), 17.81% faster in the 1600M (at 105), and 16.83% faster in the 3200M (at 106).

C. Men jump higher and farther.

29. Jumping involves both leg strength and speed as positive factors, with body weight of course a factor working against jump height. Despite their substantially greater body weight, males enjoy an even greater advantage in jumping than in running. Handelsman 2018 at 813, looking at youth and young adults, and Thibault 2010 at 217, looking at Olympic performances, both found male advantages in the range of 15%-20%. See also Tønnessen 2015 (approximately 19%); Handelsman 2017 (19%); Hilton 2021 at 201 (18%). Looking at the vertical jump called for in volleyball, research on elite volleyball players found that males jumped on average 50% higher during an "attack" at the net than did females. (Sattler 2015; see also Hilton 2021 at 203 (33% higher vertical jump).)

30. Higerd (2021) in an evaluation of high school high jump performance available through the track and field database athletic.net®, which included five states (CA, FL, MN, NY, WA), over three years (2017 – 2019) (at 82) observed that in 23,390 females and 26,843 males, females jumped an average of 1.35 m and males jumped an average of 1.62 m, for an 18.18% performance advantage for males (at 96). In an evaluation of long jump performance in 45,705 high school females and 54,506 high school males the females jumped an average of 4.08 m and males jumped an average of 5.20 m, for a 24.14% performance advantage for males (at 97).

31. The combined male advantage of body height and jump height means, for example, that a total of seven women in the WNBA have ever dunked a basketball in the regulation 10 foot hoop,[5] while the ability to dunk appears to be almost universal among NBA players: "Since the 1996–97 season (the earliest data is available from Basketball-Reference.com), 1,801 different [NBA] players have combined for 210,842 regular-season dunks, and 1,259 out of 1,367 players (or 92%) who have played at least 1,000 minutes have dunked at least once."[6]

D. Men throw, hit, and kick faster and farther.

32. Strength, arm-length, and speed combine to give men a large advantage over women in throwing. This has been measured in a number of studies.

33. One study of elite male and female baseball pitchers showed that men throw baseballs 35% faster than women—81 miles/hour for men vs. 60 miles/hour for women. (Chu 2009.) By age 12, "boys' throwing velocity is already between 3.5 and 4 standard deviation units higher than the girls'." (Thomas 1985 at 276.) By age seventeen, the *average* male can throw a ball farther than 99% of seventeen-year-old females. (Lombardo 2018; Chu 2009; Thomas 1985 at 268.) Looking at publicly available data, Hilton & Lundberg found that in both baseball pitching and the field hockey "drag flick," the *record* ball speeds achieved by males are more than 50% higher than those achieved by females. (Hilton 2021 at 202-203.)

34. Men achieve serve speeds in tennis more that 15% faster than women; and likewise in golf achieve ball speeds off the tee more than 15% faster than women. (Hilton 2021 at 202.)

35. Males are able to throw a javelin more than 30% farther than females. (Lombardo 2018 Table 2; Hilton 2021 at 203.)

36. Men serve and spike volleyballs with higher velocity than women, with a performance advantage in the range of 29-34%. (Hilton 2021 at 204 Fig. 1.)

37. Men are also able to kick balls harder and faster. A study comparing collegiate soccer players found that males kick the ball with an average 20% greater velocity than females. (Sakamoto 2014.)

---

[5] https://www.espn.com/wnba/story/_/id/32258450/2021-wnba-playoffs-brittney-griner-owns-wnba-dunking-record-coming-more.

[6] https://www.si.com/nba/2021/02/22/nba-non-dunkers-patty-mills-tj-mcconnell-steve-novak-daily-cover

E. Males exhibit faster reaction times.

38. Interestingly, men enjoy an additional advantage over women in reaction time–an attribute not obviously related to strength or metabolism (e.g. $V0_2max$). "Reaction time in sports is crucial in both simple situations such as the gun shot in sprinting and complex situations when a choice is required. In many team sports this is the foundation for tactical advantages which may eventually determine the outcome of a game." (Dogan 2009 at 92.) "Reaction times can be an important determinant of success in the 100m sprint, where medals are often decided by hundredths or even thousandths of a second." (Tønnessen 2013 at 885.)

39. The existence of a sex-linked difference in reaction times is consistent over a wide range of ages and athletic abilities. (Dykiert 2012.) Even by the age of 4 or 5, in a ruler-drop test, males have been shown to exhibit 4% to 6% faster reaction times than females. (Latorre-Roman 2018.) In high school athletes taking a common baseline "ImPACT" test, males showed 3% faster reaction times than females. (Mormile 2018.) Researchers have found a 6% male advantage in reaction times of both first-year medical students (Jain 2015) and world-class sprinters (Tønnessen 2013).

40. Most studies of reaction times use computerized tests which ask participants to hit a button on a keyboard or to say something in response to a stimulus. One study on NCAA athletes measured "reaction time" by a criterion perhaps more closely related to athletic performance–that is, how fast athletes covered 3.3 meters after a starting signal. Males covered the 3.3 meters 10% faster than females in response to a visual stimulus, and 16% faster than females in response to an auditory stimulus. (Spierer 2010.)

41. Researchers have speculated that sex-linked differences in brain structure, as well as estrogen receptors in the brain, may be the source of the observed male advantage in reaction times, but at present this remains a matter of speculation and hypothesis. (Mormile at 19; Spierer at 962.)

III. Men have large measured physiological differences compared to women which demonstrably or likely explain their performance advantages.

42. No single physiological characteristic alone accounts for all or any one of the measured advantages that men enjoy in athletic performance. However, scientists have identified and measured a number of physiological factors that contribute to superior male performance.

A. Men are taller and heavier than women

43. In some sports, such as basketball and volleyball, height itself provides competitive advantage. While some women are taller than some men, based on data from 20 countries in North America, Europe, East Asia, and Australia, the 50th percentile for body height for women is 164.7 cm (5 ft 5 inches) and the 50th percentile for body height for men is 178.4 cm (5 ft 10 inches). Helping to illustrate the inherent height difference between men and women, from the same data analysis, the 95th percentile for body height for women is 178.9 cm (5 feet 10.43 inches), which is only 0.5 cm taller than the 50th percentile for men (178.4 cm; 5 feet 10.24 inches), while the 95th percentile for body height for men is 193.6 cm (6 feet 4.22 inches). (Roser 2013.)

44. To look at a specific athletic population, an evaluation of NCAA Division 1 basketball players compared 68 male guards and 59 male forwards to 105 female guards and 91 female forwards, and found that on average the male guards were 187.4 ± 7.0 cm tall and weighed 85.2 ± 7.4 kg while the female guards were 171.6 ± 5.0 cm tall and weighed 68.0 ± 7.4 kg. The male forwards were 201.7 ± 4.0 cm tall and weighed 105.3 ± 5.9 kg while the female forwards were 183.5 ± 4.4 cm tall and weighed 82.2 ± 12.5 kg. (Fields 2018 at 3.)

B. Males have larger and longer bones, stronger bones, and different bone configuration.

45. Obviously, males on average have longer bones. "Sex differences in height have been the most thoroughly investigated measure of bone size, as adult height is a stable, easily quantified measure in large population samples. Extensive twin studies show that adult height is highly heritable with predominantly additive genetic effects that diverge in a sex-specific manner from the age of puberty onwards." (Handelsman 2018 at 818.) "Pubertal testosterone exposure leads to an ultimate average greater height in men of 12–15 centimeters, larger bones, greater muscle mass, increased strength and higher hemoglobin levels." (Gooren 2011 at 653.)

46. "Men have distinctively greater bone size, strength, and density than do women of the same age. As with muscle, sex differences in bone are absent prior to puberty but then accrue progressively from the onset of male puberty due to the sex difference in exposure to adult male circulating testosterone concentrations." (Handelsman 2018 at 818.)

47. "[O]n average men are 7% to 8% taller with longer, denser, and stronger bones, whereas women have shorter humerus and femur cross-sectional

areas being 65% to 75% and 85%, respectively, those of men." (Handelsman 2018 at 818.)

48. Greater height, leg, and arm length themselves provide obvious advantages in several sports. But male bone geometry also provides less obvious advantages. "The major effects of men's larger and stronger bones would be manifest via their taller stature as well as the larger fulcrum with greater leverage for muscular limb power exerted in jumping, throwing, or other explosive power activities." (Handelsman 2018 at 818.)

49. Male advantage in bone size is not limited to length, as larger bones provide the mechanical framework for larger muscle mass. "From puberty onwards, men have, on average, 10% more bone providing more surface area. The larger surface area of bone accommodates more skeletal muscle so, for example, men have broader shoulders allowing more muscle to build. This translates into 44% less upper body strength for women, providing men an advantage for sports like boxing, weightlifting and skiing. In similar fashion, muscle mass differences lead to decreased trunk and lower body strength by 64% and 72%, respectively in women. These differences in body strength can have a significant impact on athletic performance, and largely underwrite the significant differences in world record times and distances set by men and women." (Knox 2019 at 397.)

50. Meanwhile, distinctive aspects of the female pelvis geometry cut against athletic performance. "[T]he widening of the female pelvis during puberty, balancing the evolutionary demands of obstetrics and locomotion, retards the improvement in female physical performance." (Handelsman 2018 at 818.) "[T]he major female hormones, oestrogens, can have effects that disadvantage female athletic performance. For example, women have a wider pelvis changing the hip structure significantly between the sexes. Pelvis shape is established during puberty and is driven by oestrogen. The different angles resulting from the female pelvis leads to decreased joint rotation and muscle recruitment ultimately making them slower." (Knox 2019 at 397.)

51. There are even sex-based differences in foot size and shape. Wunderlich & Cavanaugh (2001) observed that a "foot length of 257 mm represents a value that is … approximately the 20th percentile men's foot lengths and the 80th percentile women's foot lengths." (607) and "For a man and a woman, both with statures of 170 cm (5 feet 7 inches), the man would have a foot that was approximately 5 mm longer and 2 mm wider than the woman." (608). Based on these, and other analyses, they conclude that "female feet and legs are not simply scaled-down versions of male feet but rather differ in a number of shape characteristics, particularly at the arch, the lateral side of the foot, the first toe, and the ball of the foot." (605) Further, Fessler et al. (2005) observed that "female foot length is consistently smaller than male foot length" (44) and concludes that

"proportionate foot length is smaller in women" (51) with an overall conclusion that "Our analyses of genetically disparate populations reveal a clear pattern of sexual dimorphism, with women consistently having smaller feet proportionate to stature than men." (53)

52. Beyond simple performance, the greater density and strength of male bones provide higher protection against stresses associated with extreme physical effort: "[S]tress fractures in athletes, mostly involving the legs, are more frequent in females, with the male protection attributable to their larger and thicker bones." (Handelsman 2018 at 818.)

C. Males have much larger muscle mass.

53. The fact that, on average, men have substantially larger muscles than women is as well known to common observation as men's greater height. But the male advantage in muscle size has also been extensively measured. The differential is large.

54. "On average, women have 50% to 60% of men's upper arm muscle cross-sectional area and 65% to 70% of men's thigh muscle cross-sectional area, and women have 50% to 60% of men's upper limb strength and 60% to 80% of men's leg strength. Young men have on average a skeletal muscle mass of >12 kg greater than age-matched women at any given body weight." (Handelsman 2018 at 812. See also Gooren 2011 at 653, Thibault 2010 at 214.)

55. "There is convincing evidence that the sex differences in muscle mass and strength are sufficient to account for the increased strength and aerobic performance of men compared with women and is in keeping with the differences in world records between the sexes." (Handelsman 2018 at 816.)

56. Once again, looking at specific and comparable populations of athletes, an evaluation of NCAA Division 1 basketball players consisting of 68 male guards and 59 male forwards, compared to 105 female guards and 91 female forwards, reported that on average the male guards had 77.7 ± 6.4 kg of fat free mass and 7.4 ± 3.1 kg fat mass while the female guards had 54.6 ± 4.4 kg fat free mass and 13.4 ± 5.4 kg fat mass. The male forwards had 89.5 ± 5.9 kg fat free mass and 15.9 ± 5.6 kg fat mass while the female forwards had 61.8 ± 5.9 kg fat free mass and 20.5 ± 7.7 kg fat mass. (Fields 2018 at 3.)

D. Females have a larger proportion of body fat.

57. While women have smaller muscles, they have proportionately more body fat, in general a negative for athletic performance. "Oestrogens also affect body

composition by influencing fat deposition. Women, on average, have higher percentage body fat, and this holds true even for highly trained healthy athletes (men 5%–10%, women 8%–15%). Fat is needed in women for normal reproduction and fertility, but it is not performance-enhancing. This means men with higher muscle mass and less body fat will normally be stronger kilogram for kilogram than women." (Knox 2019 at 397.)

58. "[E]lite females have more (<13 vs. <5 %) body fat than males. Indeed, much of the difference in [maximal oxygen uptake] between males and females disappears when it is expressed relative to lean body mass. . . . Males possess on average 7–9 % less percent body fat than females." (Lepers 2013 at 853.)

59. Knox et al. observe that both female pelvis shape and female body fat levels "disadvantage female athletes in sports in which speed, strength and recovery are important," (Knox 2019 at 397), while Tønnessen et al. describe the "ratio between muscular power and total body mass" as "critical" for athletic performance. (Tønnessen 2015 at 7.)

E. Males are able to metabolize and release energy to muscles at a higher rate due to larger heart and lung size, and higher hemoglobin concentrations.

60. While advantages in bone size, muscle size, and body fat are easily perceived and understood by laymen, scientists also measure and explain the male athletic advantage at a more abstract level through measurements of metabolism, or the ability to deliver energy to muscles throughout the body.

61. Energy release at the muscles depends centrally on the body's ability to deliver oxygen to the muscles, where it is essential to the complex chain of biochemical reactions that make energy available to power muscle fibers. Men have multiple distinctive physiological attributes that together give them a large advantage in oxygen delivery.

62. Oxygen is taken into the blood in the lungs. Men have greater capability to take in oxygen for multiple reasons. "**[L]ung capacity** [is] larger in men because of a lower diaphragm placement due to Y-chromosome genetic determinants." (Knox 2019 at 397.) Supporting larger lung capacity, men have "greater cross-sectional area of the trachea"; that is, they can simply move more air in and out of their lungs in a given time. (Hilton 2021 at 201.)

63. More, male lungs provide superior oxygen exchange even for a given volume: "The greater lung volume is complemented by testosterone-driven **enhanced alveolar multiplication** rate during the early years of life. Oxygen exchange takes place between the air we breathe and the bloodstream at the alveoli,

so more alveoli allows more oxygen to pass into the bloodstream. Therefore, the greater lung capacity allows more air to be inhaled with each breath. This is coupled with an improved uptake system allowing men to absorb more oxygen." (Knox 2019 at 397.)

64. "Once in the blood, oxygen is carried by haemoglobin. **Haemoglobin concentrations** are directly modulated by testosterone so men have higher levels and can carry more oxygen than women." (Knox 2019 at 397.) "It is well known that levels of circulating hemoglobin are androgen-dependent and consequently higher in men than in women by 12% on average…. Increasing the amount of hemoglobin in the blood has the biological effect of increasing oxygen transport from lungs to tissues, where the increased availability of oxygen enhances aerobic energy expenditure." (Handelsman 2018 at 816.) (See also Lepers 2013 at 853; Handelsman 2017 at 71.) "It may be estimated that as a result the average maximal oxygen transfer will be ~10% greater in men than in women, which has a direct impact on their respective athletic capacities." (Handelsman 2018 at 816.)

65. But the male metabolic advantage is further multiplied by the fact that men are also able to **circulate more blood per second** than are women. "Oxygenated blood is pumped to the active skeletal muscle by the heart. The left ventricle chamber of the heart is the reservoir from which blood is pumped to the body. The larger the left ventricle, the more blood it can hold, and therefore, the more blood can be pumped to the body with each heartbeat, a physiological parameter called 'stroke volume'.The female heart size is, on average, 85% that of a male resulting in the stroke volume of women being around 33% less." (Knox 2018 at 397.) Hilton cites different studies that make the same finding, reporting that men on average can pump 30% more blood through their circulatory system per minute ("cardiac output") than can women. (Hilton 2021 at 202.)

66. Finally, at the cell where the energy release is needed, men appear to have yet another advantage. "Additionally, there is experimental evidence that testosterone increases . . . **mitochondrial biogenesis**, myoglobin expression, and IGF-1 content, which may augment energetic and power generation of skeletal muscular activity." (Handelsman 2018 at 811.)

67. "Putting all of this together, men have a much more efficient cardiovascular and respiratory system." (Knox 2019 at 397.) A widely accepted measurement that reflects the combined effects of all these respiratory, cardiovascular, and metabolic advantages is referred to as "$V0_2max$," which refers to the maximum rate at which an individual can consume oxygen during aerobic

exercise.[7] Looking at 11 separate studies, including both trained and untrained individuals, Pate et al. concluded that men have a 50% higher $V0_2$max than women on average, and a 25% higher $V0_2$max in relation to body weight. (Pate 1984 at 92. See also Hilton 2021 at 202.)

IV. The role of testosterone in the development of male advantages in athletic performance.

68. The following tables of reference ranges for circulating testosterone in males and females are presented to help provide context for some of the subsequent information regarding athletic performance and physical fitness in children, youth, and adults, and regarding testosterone suppression in transwomen and athletic regulations. These data were obtained from the Mayo Clinic Laboratories (available at https://www.mayocliniclabs.com/test-catalog/overview/83686#Clinical-and-Interpretive, accessed January 14, 2022).

Reference ranges for serum testosterone concentrations in males and females.

Age	Males	Females
0 – 5 months	2.6 – 13.9 nmol/l	0.7 – 2.8 nmol/l
6 months – 9 years	0.2 – 0.7 nmol/l	0.2 – 0.7 nmol/l
10 – 11 years	0.2 – 4.5 nmol/l	0.2 – 1.5 nmol/l
12 -13 years	0.2 – 27.7 nmol/l	0.2 – 2.6 nmol/l
14 years	0.2 – 41.6 nmol/l	0.2 – 2.6 nmol/l
15 – 16 years	3.5 – 41.6 nmol/l	0.2 – 2.6 nmol/l
17 – 18 years	10.4 – 41.6 nmol/l	0.7 – 2.6 nmol/l
19 years and older	8.3 – 32.9 nmol/l	0.3 – 2.1 nmol/l

Please note that testosterone concentrations are sometimes expressed in units of ng/dl, and 1 nmol/l = 28.85 ng/dl.

69. Tanner Stages can be used to help evaluate the onset and progression of puberty and may be more helpful in evaluating normal testosterone concentrations than age in adolescents. "Puberty onset (transition from Tanner stage I to Tanner stage II) occurs for boys at a median age of 11.5 years and for girls

[7] $V0_2$max is "based on hemoglobin concentration, total blood volume, maximal stroke volume, cardiac size/mass/compliance, skeletal muscle blood flow, capillary density, and mitochondrial content." International Statement, *The Role of Testosterone in Athletic Performance* (January 2019), available at https://law.duke.edu/sites/default/files/centers/sportslaw/Experts_T_Statement_2019.pdf.

at a median age of 10.5 years. . . . Progression through Tanner stages is variable. Tanner stage V (young adult) should be reached by age 18." (https://www.mayocliniclabs.com/test-catalog/overview/83686#Clinical-and-Interpretive, accessed January 14, 2022).

Reference Ranges for serum testosterone concentrations by Tanner stage

Tanner Stage	Males	Females
I (prepubertal)	0.2 – 0.7 nmol/l	0.7 – 0.7 nmol/l
II	0.3 – 2.3 nmo/l	0.2 – 1.6 nmol/l
III	0.9 – 27.7 nmol/l	0.6 – 2.6 nmol/l
IV	2.9 – 41.6 nmol/l	0.7 – 2.6 nmol/l
V (young adult)	10.4 – 32.9 nmol/	0.4 – 2.1 nmol/l

70. Senefeld et al. (2020 at 99) state that "Data on testosterone levels in children and adolescents segregated by sex are scarce and based on convenience samples or assays with limited sensitivity and accuracy." They therefore "analyzed the timing of the onset and magnitude of the divergence in testosterone in youths aged 6 to 20 years by sex using a highly accurate assay" (isotope dilution liquid chromatography tandem mass spectrometry). Senefeld observed a significant difference beginning at age 11, which is to say about fifth grade.

Serum testosterone concentrations (nmol/L) in youths aged 6 to 20 years measured using isotope dilution liquid chromatography tandem mass spectrometry (Senefeld et al. ,2020, at 99)

	Boys			Girls		
Age (y)	5th	50th	95th	5th	50th	95th
6	0.0	0.1	0.2	0.0	0.1	0.2
7	0.0	0.1	0.2	0.0	0.1	0.3
8	0.0	0.1	0.3	0.0	0.1	0.3
9	0.0	0.1	0.3	0.1	0.2	0.6
10	0.1	0.2	2.6	0.1	0.3	0.9
11	0.1	0.5	11.3	0.2	0.5	1.3
12	0.3	3.6	17.2	0.2	0.7	1.4
13	0.6	9.2	21.5	0.3	0.8	1.5
14	2.2	11.9	24.2	0.3	0.8	1.6
15	4.9	13.2	25.8	0.4	0.8	1.8
16	5.2	14.9	24.1	0.4	0.9	2.0
17	7.6	15.4	27.0	0.5	1.0	2.0
18	9.2	16.3	25.5	0.4	0.9	2.1
19	8.1	17.2	27.9	0.4	0.9	2.3
20	6.5	17.9	29.9	0.4	1.0	3.4

A. Boys exhibit advantages in athletic performance even before puberty.

71. It is often said or assumed that boys enjoy no significant athletic advantage over girls before puberty. However, this is not true. Writing in their seminal work on the physiology of elite young female athletes, McManus and Armstrong (2011) reviewed the differences between boys and girls regarding bone density, body composition, cardiovascular function, metabolic function, and other physiologic factors that can influence athletic performance. They stated, "At birth, boys tend to have a greater lean mass than girls. This difference remains small but detectable throughout childhood with about a 10% greater lean mass in boys than girls prior to puberty." (28) "Sexual dimorphism underlies much of the physiologic response to exercise," and most importantly these authors concluded that, "Young girl athletes are not simply smaller, less muscular boys." (23)

72. Certainly, boys' physiological and performance advantages increase rapidly from the beginning of puberty until around age 17-19. But much data and multiple studies show that significant physiological differences, and significant male athletic performance advantages in certain areas, exist before significant developmental changes associated with male puberty have occurred.

73. Starting at birth, girls have more body fat and less fat-free mass than boys. Davis et al. (2019) in an evaluation of 602 infants reported that at birth and age 5 months, infant boys have larger total body mass, body length, and fat-free mass while having lower percent body fat than infant girls. In an evaluation of 20 boys and 20 girls ages 3-8 years old, matched for age, height, and body weight Taylor et al. (Taylor 1997) reported that the "boys had significantly less fat, a lower % body fat and a higher bone-free lean tissue mass than the girls" when "expressed as a percentage of the average fat mass of the boys", the girls' fat mass was 52% higher than the boys "…while the bone-free lean tissue mass was 9% lower" (at 1083.) In an evaluation of 376 prepubertal [Tanner Stage 1] boys and girls, Taylor et al. (2010) observed that the boys had 21.6% more lean mass, and 13% less body fat (when expressed as percent of total body mass) than did the girls. In a review of 22 peer reviewed publications on the topic, Staiano and Katzmarzyk (2012) conclude that "… girls have more T[otal]B[ody]F[at] than boys throughout childhood and adolescence. (at 4.)

74. In the seminal textbook, *Growth, Maturation, and Physical Activity*, Malina et al. (2004) present a summary of data from Gauthier et al. (1983) which present data from "a national sample of Canadian children and youth" demonstrating that from ages 7 to17, boys have a higher aerobic power output than do girls of the same ages when exercise intensity is measured using heart rate

(Malina at 242.) That is to say, that at a heart rate of 130 beats per minute, or 150, or 170, a 7 to 17 year old boy should be able to run, bike, or swim faster than a similarly aged girl.

75. Considerable data from school-based fitness testing exists showing that prepubertal boys outperform comparably aged girls in tests of muscular strength, muscular endurance, and running speed. These sex-based differences in physical fitness are relevant to the current issue of sex-based sports categories because, as stated by Lesinski et al. (2020), in an evaluation "of 703 male and female elite young athletes aged 8–18" (1) "fitness development precedes sports specialization" (2) and further observed that "males outperformed females in C[ounter]M[ovement]J[ump], D[rop]J[ump], C[hange]o[f]D[irection speed] performances and hand grip strength." (5).

76. Tambalis et al. (2016) states that "based on a large data set comprising 424,328 test performances" (736) using standing long jump to measure lower body explosive power, sit and reach to measure flexibility, timed 30 second sit ups to measure abdominal and hip flexor muscle endurance, 10 x 5 meter shuttle run to evaluate speed and agility, and multi-stage 20 meter shuttle run test to estimate aerobic performance (738). "For each of the fitness tests, performance was better in boys compared with girls ($p < 0.001$), except for the S[it and] R[each] test ($p < 0.001$)." (739) In order to illustrate that the findings of Tambalis (2016) are not unique to children in Greece, the authors state "Our findings are in accordance with recent studies from Latvia [ ] Portugal [ ] and Australia [Catley & Tomkinson (2013)]."(744).

77. The 20-m multistage fitness test is a commonly used maximal running aerobic fitness test used in the Eurofit Physical Fitness Test Battery and the FitnessGram Physical Fitness test. It is also known as the 20-meter shuttle run test, PACER test, or beep test (among other names; this is not the same test as the shuttle run in the Presidential Fitness Test). This test involves continuous running between two lines 20 meters apart in time to recorded beeps. The participants stand behind one of the lines facing the second line and begin running when instructed by the recording. The speed at the start is quite slow. The subject continues running between the two lines, turning when signaled by the recorded beeps. After about one minute, a sound indicates an increase in speed, and the beeps will be closer together. This continues each minute (level). If the line is reached before the beep sounds, the subject must wait until the beep sounds before continuing. If the line is not reached before the beep sounds, the subject is given a warning and must continue to run to the line, then turn and try to catch up with the pace within two more 'beeps'. The subject is given a warning the first time they fail to reach the line (within 2 meters) and eliminated after the second warning.

78. To illustrate the sex-based performance differences observed by Tambalis, I have prepared the following table showing the number of laps completed in the 20 m shuttle run for children ages 6-18 years for the low, middle, and top decile (Tambalis 2016 at 740 & 742), and have calculated the percent difference between the boys and girls using the same equation as Millard-Stafford (2018).

Performance difference between boys and girls ÷ Girls performance

Number of laps completed in the 20m shuttle run for children ages 6-18 years

	Male			Female			Male-Female % Difference		
Age	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile
6	4	14	31	4.0	12.0	26.0	0.0%	16.7%	19.2%
7	8	18	38	8.0	15.0	29.0	0.0%	20.0%	31.0%
8	9	23	47	9.0	18.0	34.0	0.0%	27.8%	38.2%
9	11	28	53	10.0	20.0	40.0	10.0%	40.0%	32.5%
10	12	31	58	11.0	23.0	43.0	9.1%	34.8%	34.9%
11	15	36	64	12.0	26.0	48.0	25.0%	38.5%	33.3%
12	15	39	69	12.0	26.0	49.0	25.0%	50.0%	40.8%
13	16	44	76	12.0	26.0	50.0	33.3%	69.2%	52.0%
14	19	50	85	12.0	26.0	50.0	58.3%	92.3%	70.0%
15	20	53	90	12.0	25.0	47.0	66.7%	112.0%	91.5%
16	20	54	90	11.0	24.0	45.0	81.8%	125.0%	100.0%
17	18	50	86	10.0	23.0	50.0	80.0%	117.4%	72.0%
18	13	48	87	8.0	23.0	39.5	62.5%	108.7%	120.3%

79. The Presidential Fitness Test was widely used in schools in the United States from the late 1950s until 2013 (when it was phased out in favor of the Presidential Youth Fitness Program and FitnessGram, both of which focus on health-related physical fitness and do not present data in percentiles). Students participating in the Presidential Fitness Test could receive "The National Physical Fitness Award" for performance equal to the 50th percentile in five areas of the fitness test, "while performance equal to the 85th percentile could receive the Presidential Physical Fitness Award." Tables presenting the 50th and 85th percentiles for the Presidential Fitness Test for males and females ages 6 – 17, and differences in performance between males and females, for curl-ups, shuttle run, 1 mile run, push-ups, and pull-ups appear in the Appendix.

80. For both the 50th percentile (The National Physical Fitness Award) and the 85th percentile (Presidential Physical Fitness Award), with the exception of curl-ups in 6-year-old children, boys outperform girls. The difference in pull-ups for the 85th percentile for ages 7 through 17 are particularly informative with boys

outperforming girls by 100% – 1200%, highlighting the advantages in upper body strength in males.

81. A very recent literature review commissioned by the five United Kingdom governmental Sport Councils concluded that while "[i]t is often assumed that children have similar physical capacity regardless of their sex, . . . large-scale data reports on children from the age of six show that young males have significant advantage in cardiovascular endurance, muscular strength, muscular endurance, speed/agility and power tests," although they "score lower on flexibility tests." (UK Sports Councils' Literature Review 2021 at 3.)

82. Hilton et al., also writing in 2021, reached the same conclusion: "An extensive review of fitness data from over 85,000 Australian children aged 9–17 years old showed that, compared with 9-year-old females, 9-year-old males were faster over short sprints (9.8%) and 1 mile (16.6%), could jump 9.5% further from a standing start (a test of explosive power), could complete 33% more push-ups in 30 [seconds] and had 13.8% stronger grip." (Hilton 2021 at 201, summarizing the findings of Catley & Tomkinson 2013.)

83. The following data are taken from Catley & Tomkinson (2013 at 101) showing the low, middle, and top decile for 1.6 km run (1.0 mile) run time for 11,423 girls and boys ages 9-17.

1.6 km run (1.0 mile) run time for 11,423 girls and boys ages 9-17

	Male			Female			Male-Female % Difference		
Age	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile
9	684	522	423	769.0	609.0	499.0	11.1%	14.3%	15.2%
10	666	511	420	759.0	600.0	494.0	12.3%	14.8%	15.0%
11	646	500	416	741.0	586.0	483.0	12.8%	14.7%	13.9%
12	621	485	408	726.0	575.0	474.0	14.5%	15.7%	13.9%
13	587	465	395	716.0	569.0	469.0	18.0%	18.3%	15.8%
14	556	446	382	711.0	567.0	468.0	21.8%	21.3%	18.4%
15	531	432	373	710.0	570.0	469.0	25.2%	24.2%	20.5%
16	514	423	366	710.0	573.0	471.0	27.6%	26.2%	22.3%
17	500	417	362	708.0	575.0	471.0	29.4%	27.5%	23.1%

84. Tomkinson et al. (2018) performed a similarly extensive analysis of literally millions of measurements of a variety of strength and agility metrics from the "Eurofit" test battery on children from 30 European countries. They provide detailed results for each metric, broken out by decile. Sampling the low, middle, and top decile, 9-year-old boys performed better than 9-year-old girls by between 6.5%

and 9.7% in the standing broad jump; from 11.4% to 16.1% better in handgrip; and from 45.5% to 49.7% better in the "bent-arm hang." (Tomkinson 2018.)

85. The Bent Arm Hang test is a measure of upper body muscular strength and endurance used in the Eurofit Physical Fitness Test Battery. To perform the Bent Arm Hang, the child is assisted into position with the body lifted to a height so that the chin is level with the horizontal bar (like a pull up bar). The bar is grasped with the palms facing away from body and the hands shoulder width apart. The timing starts when the child is released. The child then attempts to hold this position for as long as possible. Timing stops when the child's chin falls below the level of the bar, or the head is tilted backward to enable the chin to stay level with the bar.

86. Using data from Tomkinson (2018; table 7 at 1452), the following table sampling the low, middle, and top decile for bent arm hang for 9- to 17-year-old children can be constructed:

Bent Arm Hang time (in seconds) for children ages 9 - 17 years

	Male			Female			Male-Female % Difference		
	10th	50th	90th	10th	50th	90th	10th	50th	90th
Age	%ile	%ile	%ile	%ile	%ile	%ile	%ile	%ile	%ile
9	2.13	7.48	25.36	1.43	5.14	16.94	48.95%	45.53%	49.70%
10	2.25	7.92	26.62	1.42	5.15	17.06	58.45%	53.79%	56.04%
11	2.35	8.32	27.73	1.42	5.16	17.18	65.49%	61.24%	61.41%
12	2.48	8.79	28.99	1.41	5.17	17.22	75.89%	70.02%	68.35%
13	2.77	9.81	31.57	1.41	5.18	17.33	96.45%	89.38%	82.17%
14	3.67	12.70	38.39	1.40	5.23	17.83	162.14%	142.83%	115.31%
15	5.40	17.43	47.44	1.38	5.35	18.80	291.30%	225.79%	152.34%
16	7.39	21.75	53.13	1.38	5.63	20.57	435.51%	286.32%	158.29%
17	9.03	24.46	54.66	1.43	6.16	23.61	531.47%	297.08%	131.51%

87. Evaluating these data, a 9-year-old boy in the 50th percentile (that is to say a 9-year-old boy of average upper body muscular strength and endurance) will perform better in the bent arm hang test than 9 through 17-year-old girls in the 50th percentile. Similarly, a 9-year-old boy in the 90th percentile will perform better in the bent arm hang test than 9 through 17-year-old girls in the 90th percentile.

88. Using data from Tomkinson et al. (2017; table 1 at 1549), the following table sampling the low, middle, and top decile for running speed in the last stage of the 20 m shuttle run for 9- to 17-year-old children can be constructed.

20 m shuttle Running speed (km/h at the last completed stage)

	Male			Female			Male-Female % Difference		
Age	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile
9	8.94	10.03	11.13	8.82	9.72	10.61	1.36%	3.19%	4.90%
10	8.95	10.13	11.31	8.76	9.75	10.74	2.17%	3.90%	5.31%
11	8.97	10.25	11.53	8.72	9.78	10.85	2.87%	4.81%	6.27%
12	9.05	10.47	11.89	8.69	9.83	10.95	4.14%	6.51%	8.58%
13	9.18	10.73	12.29	8.69	9.86	11.03	5.64%	8.82%	11.42%
14	9.32	10.96	12.61	8.70	9.89	11.07	7.13%	10.82%	13.91%
15	9.42	11.13	12.84	8.70	9.91	11.11	8.28%	12.31%	15.57%
16	9.51	11.27	13.03	8.71	9.93	11.14	9.18%	13.49%	16.97%
17	9.60	11.41	13.23	8.72	9.96	11.09	10.09%	14.56%	19.30%

89. Evaluating these data, a 9-year-old boy in the 50th percentile (that is to say a 9-year-old boy of average running speed) will run faster in the final stage of the 20 m shuttle run than 9 through 17-year-old girls in the 50th percentile. Similarly, a 9-year-old boy in the 90th percentile will run faster in the final stage of the 20-m shuttle run than 9 through 15, and 17-year-old girls in the 90th percentile and will be 0.01 km/h (0.01%) slower than 16-year-old girls in the 90th percentile.

90. Just using these two examples for bent arm hang and 20-m shuttle running speed (Tomkinson 2107, Tomkinson 2018) based on large sample sizes (thus having tremendous statistical power) it becomes apparent that a 9-year-old boy will be very likely to outperform similarly trained girls of his own age and older in athletic events involving upper body muscle strength and/or running speed.

91. Another report published in 2014 analyzed physical fitness measurements of 10,302 children aged 6 -10.9 years of age, from the European countries of Sweden, Germany, Hungary, Italy, Cyprus, Spain, Belgium, and Estonia. (De Miguel-Etayo et al. 2014.) The authors observed "… that boys performed better than girls in speed, lower- and upper-limb strength and cardiorespiratory fitness." (57) The data showed that for children of comparable fitness (i.e. 99th percentile boys vs. 99th percentile girls, 50th percentile boys vs. 50th percentile girls, etc.) the boys outperform the girls at every age in measurements of handgrip strength, standing long jump, 20-m shuttle run, and predicted VO_2max (pages 63 and 64, respectively). For clarification, VO_2max is the maximal oxygen consumption, which correlates to 30-40% of success in endurance sports.

92. The standing long jump, also called the Broad Jump, is a common and easy to administer test of explosive leg power used in the Eurofit Physical Fitness Test Battery and in the NFL Combine. In the standing long jump, the participant stands behind a line marked on the ground with feet slightly apart. A two-foot take-

off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The participant attempts to jump as far as possible, landing on both feet without falling backwards. The measurement is taken from takeoff line to the nearest point of contact on the landing (back of the heels) with the best of three attempts being scored.

93. Using data from De Miguel-Etayo et al. (2014, table 3 at 61), which analyzed physical fitness measurements of 10,302 children aged 6 -10.9 years of age, from the European countries of Sweden, Germany, Hungary, Italy, Cyprus, Spain, Belgium, and Estonia, the following table sampling the low, middle, and top decile for standing long jump for 6- to 9-year-old children can be constructed:

Standing Broad Jump (cm) for children ages 6-9 years

	Male			Female			Male-Female % Difference		
Age	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile
6-<6.5	77.3	103.0	125.3	69.1	93.8	116.7	11.9%	9.8%	7.4%
6.5-<7	82.1	108.0	130.7	73.6	98.7	121.9	11.5%	9.4%	7.2%
7-<7.5	86.8	113.1	136.2	78.2	103.5	127.0	11.0%	9.3%	7.2%
7.5-<8	91.7	118.2	141.6	82.8	108.3	132.1	10.7%	9.1%	7.2%
8-<8.5	96.5	123.3	146.9	87.5	113.1	137.1	10.3%	9.0%	7.1%
8.5-<9	101.5	128.3	152.2	92.3	118.0	142.1	10.0%	8.7%	7.1%

94. Another study of Eurofit results for over 400,000 Greek children reported similar results. "[C]ompared with 6-year-old females, 6-year-old males completed 16.6% more shuttle runs in a given time and could jump 9.7% further from a standing position." (Hilton 2021 at 201, summarizing findings of Tambalis et al. 2016.)

95. Silverman (2011) gathered hand grip data, broken out by age and sex, from a number of studies. Looking only at the nine direct comparisons within individual studies tabulated by Silverman for children aged 7 or younger, in eight of these the boys had strength advantages of between 13 and 28 percent, with the remaining outlier recording only a 4% advantage for 7-year-old boys. (Silverman 2011 Table 1.)

96. To help illustrate the importance of one specific measure of physical fitness in athletic performance, Pocek (2021) stated that to be successful, volleyball "players should distinguish themselves, besides in skill level, in terms of above-average body height, upper and lower muscular power, speed, and agility. Vertical jump is a fundamental part of the spike, block, and serve." (8377) Pocek further stated that "relative vertical jumping ability is of great importance in volleyball regardless of the players' position, while absolute vertical jump values can differentiate players not only in terms of player position and performance level but in their career trajectories." (8382)

97. Using data from Ramírez-Vélez (2017; table 2 at 994) which analyzed vertical jump measurements of 7,614 healthy Colombian schoolchildren aged 9 -17.9 years of age the following table sampling the low, middle, and top decile for vertical jump can be constructed:

Vertical Jump Height (cm) for children ages 9 - 17 years

	Male			Female			Male-Female % Difference		
Age	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile
9	18.0	24.0	29.5	16.0	22.3	29.0	12.5%	7.6%	1.7%
10	19.5	25.0	32.0	18.0	24.0	29.5	8.3%	4.2%	8.5%
11	21.0	27.0	32.5	19.5	25.0	31.0	7.7%	8.0%	4.8%
12	22.0	27.5	34.5	20.0	25.5	31.5	10.0%	7.8%	9.5%
13	23.0	30.5	39.0	19.0	25.5	32.0	21.1%	19.6%	21.9%
14	23.5	32.0	41.5	20.0	25.5	32.5	17.5%	25.5%	27.7%
15	26.0	35.5	43.0	20.2	26.0	32.5	28.7%	36.5%	32.3%
16	28.0	36.5	45.1	20.5	26.5	33.0	36.6%	37.7%	36.7%
17	28.0	38.0	47.0	21.5	27.0	35.0	30.2%	40.7%	34.3%

98. Similarly, using data from Taylor (2010; table 2, at 869) which analyzed vertical jump measurements of 1,845 children aged 10 -15 years in primary and secondary schools in the East of England, the following table sampling the low, middle, and top decile for vertical jump can be constructed:

Vertical Jump Height (cm) for children 10 -15 years

	Male			Female			Male-Female % Difference		
Age	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile
10	16.00	21.00	29.00	15.00	22.00	27.00	6.7%	-4.5%	7.4%
11	20.00	27.00	34.00	19.00	25.00	32.00	5.3%	8.0%	6.3%
12	23.00	30.00	37.00	21.00	27.00	33.00	9.5%	11.1%	12.1%
13	23.00	32.00	40.00	21.00	26.00	34.00	9.5%	23.1%	17.6%
14	26.00	36.00	44.00	21.00	28.00	34.00	23.8%	28.6%	29.4%
15	29.00	37.00	44.00	21.00	28.00	39.00	38.1%	32.1%	12.8%

99. As can be seen from the data from Ramírez-Vélez (2017) and Taylor (2010), males consistently outperform females of the same age and percentile in vertical jump height. Both sets of data show that an 11-year-old boy in the 90th percentile for vertical jump height will outperform girls in the 90th percentile at ages 11 and 12, and will be equal to girls at ages 13, 14, and possibly 15. These data indicate that an 11-year-old would be likely to have an advantage over girls of the same age and older in sports such as volleyball where "absolute vertical jump

values can differentiate players not only in terms of player position and performance level but in their career trajectories." (Pocek 2021 at 8382.)

100. Boys also enjoy an advantage in throwing well before puberty. "Boys exceed girls in throwing velocity by 1.5 standard deviation units as early as 4 to 7 years of age. . . The boys exceed the girls [in throwing distance] by 1.5 standard deviation units as early as 2 to 4 years of age." (Thomas 1985 at 266.) This means that the average 4- to 7-year-old boy can out-throw approximately 87% of all girls of his age.

101. Record data from USA Track & Field indicate that boys outperform girls in track events even in the youngest age group for whom records are kept (age 8 and under).[8]

American Youth Outdoor Track & Field Record times in age groups 8 and under (time in seconds)

Event	Boys	Girls	Difference
100M	13.65	13.78	0.95%
200M	27.32	28.21	3.26%
400M	62.48	66.10	5.79%
800M	148.59	158.11	6.41%
1500M	308.52	314.72	2.01%
Mean			3.68%

102. Looking at the best times within a single year shows a similar pattern of consistent advantage for even young boys. I consider the 2018 USATF Region 8 Junior Olympic Championships for the youngest age group (8 and under).[9]

2018 USATF Region 8 Junior Olympic Championships for the 8 and under age group

Event	Boys	Girls	Difference
100M	15.11	15.64	3.51%
200M	30.79	33.58	9.06%
400M	71.12	77.32	8.72%
800M	174.28	180.48	3.56%
1500M	351.43	382.47	8.83%
Mean			6.74%

[8] http://legacy.usatf.org/statistics/records/view.asp?division=american&location=outdoor%20track%20%26%20field&age=youth&sport=TF

[9] https://www.athletic.net/TrackAndField/meet/384619/results/m/1/100m

[9] https://www.athletic.net/CrossCountry/Division/List.aspx?DivID=62211

103. Using Athletic.net[9], for 2021 Cross Country and Track & Field data for boys and girls in the 7-8, 9-10, and 11-12 year old age group club reports, and for 5th, 6th, and 7th grade for the whole United States I have compiled the tables for 3000 m events, and for the 100-m, 200-m, 400-m, 800-m, 1600-m, 3000-m, long jump, and high jump Track and Field data to illustrate the differences in individual athletic performance between boys and girls, all of which appear in the Appendix. The pattern of males outperforming females was consistent across events, with rare anomalies, only varying in the magnitude of difference between males and females.

104. Similarly, using Athletic.net, for 2021 Track & Field data for boys and girls in the 6th grade for the state of West Virginia, I have compiled tables, which appear in the appendix, comparing the performance of boys and girls for the 100-m, 200-m, 400-m, 800-m, 1600-m, and 3200-m running events in which the 1st place boy was consistently faster than the 1st place girl, and the average performance of the top 10 boys was consistently faster than the average performance for the top 10 girls. Based on the finishing times for the 1st place boy and girl in the 6th grade in West Virginia 1600-m race, and extrapolating the running time to a running pace, the 1st place boy would be expected to finish 273 m in front of the 1st place girl, which is 2/3 of a lap on a standard 400-m track, or almost the length of 3 football fields. In comparison, the 1st place boy would finish 66 m in front of the 2nd place boy, and the 1st place girl would finish 20 m in front of the 2nd place girl.

Top 10 West Virginia boys and girls 6th grade outdoor track for 2021 (time in seconds)

	100 m			200 m			400 m		
	Boys	Girls		Boys	Girls		Boys	Girls	
1	13.18	14.00	Difference	26.97	29.28	Difference	60.04	65.50	Difference
2	13.94	14.19	between #1	29.38	30.05	between #1	60.48	67.51	between #1
3	14.07	14.47	boy and # 1	30.09	30.34	boy and # 1	66.26	68.60	boy and # 1
4	14.44	14.86	girl	30.10	30.73	girl	67.12	70.43	girl
5	14.46	14.92	5.9%	30.24	31.00	7.9%	68.28	71.09	8.3%
6	14.53	15.04		30.38	31.04		68.36	71.38	
7	14.75	15.04	Average	30.54	31.10	Average	69.65	73.61	Average
8	14.78	15.20	difference	30.69	31.10	difference	69.70	73.87	difference
			boys vs			boys vs			boys vs
9	14.84	15.25	girls	30.74	31.35	girls	69.76	74.07	girls
10	14.94	15.28	2.9%	30.99	31.64	2.4%	70.63	74.21	5.6%

	800 m			1600 m			3200 m		
	Boys	Girls		Boys	Girls		Boys	Girls	
1	147.2	164.5	Difference	305.5	357.8	Difference	678.4	776.6	Difference
2	147.9	166.1	between #1	318.1	361.6	between #1	750.0	809.8	between #1
3	152.1	167.2	boy and # 1	322.0	379.8	boy and # 1	763.3	811.0	boy and # 1
4	153.2	170.2	girl	336.0	385.2	girl	766.3	843.0	girl
5	155.3	171.0	10.6%	342.2	390.2	14.6%	771.7	850.6	12.7%
6	159.5	171.5		348.0	392.0		782.8	852.1	
7	159.9	174.8	Average	356.6	393.3	Average	794.1	858.0	Average
8	167.8	174.9	difference	357.5	395.7	difference	803.0	862.8	difference
			boys vs			boys vs			boys vs
9	169.2	175.9	girls	362.4	398.1	girls	812.1	869.9	girls
10	172.6	177.6	7.5%	366.0	403.2	11.5%	814.3	883.3	8.1%

105. As serious runners will recognize, differences of 3%, 5%, or 8% are not easily overcome. During track competition the difference between first and second place, or second and third place, or third and fourth place (and so on) is often 0.5 - 0.7%, with some contests being determined by as little as 0.01%.

106. I performed an analysis of running events (consisting of the 100-m, 200-m, 400-m, 800-m, 1500-m, 5000-m, and 10,000-m) in the Division 1, Division 2, and Division 3 NCAA Outdoor championships for the years of 2010-2019: the mean difference between 1st and 2nd place was 0.48% for men and 0.86% for women. The mean difference between 2nd and 3rd place was 0.46% for men and 0.57% for women. The mean difference between 3rd place and 4th place was 0.31% for men and 0.44% for women. The mean difference between 1st place and 8th place (the last place to earn the title of All American) was 2.65% for men and 3.77% for women. (Brown et al. Unpublished observations, to be presented at the 2022 Annual Meeting of the American College of Sports Medicine.)

107. A common response to empirical data showing pre-pubertal performance advantages in boys is the argument that the performance of boys may

represent a social–cultural bias for boys to be more physically active, rather than representing inherent sex-based differences in pre-pubertal physical fitness. However, the younger the age at which such differences are observed, and the more egalitarian the culture within which they are observed, the less plausible this hypothesis becomes. Eiberg et al. (2005) measured body composition, VO_2max, and physical activity in 366 Danish boys and 332 Danish girls between the ages of 6 and 7 years old. Their observations indicated that VO_2max was 11% higher in boys than girls. When expressed relative to body mass the boys' VO_2max was still 8% higher than the girls. The authors stated that "…no differences in haemoglobin or sex hormones[10] have been reported in this age group," yet "… when children with the same VO_2max were compared, boys were still more active, and in boys and girls with the same P[hysical] A[ctivity] level, boys were fitter." (728). These data indicate that in pre-pubertal children, in a very egalitarian culture regarding gender roles and gender norms, boys still have a measurable advantage in regards to aerobic fitness when known physiological and physical activity differences are accounted for.

108. And, as I have mentioned above, even by the age of 4 or 5, in a ruler-drop test, boys exhibit 4% to 6% faster reaction times than girls. (Latorre-Roman 2018.)

109. When looking at the data on testosterone concentrations previously presented, along with the data on physical fitness and athletic performance presented, boys have advantages in athletic performance and physical fitness before there are marked differences in testosterone concentrations between boys and girls.

110. For the most part, the data I review above relate to pre-pubertal children. Today, we also face the question of inclusion in female athletics of males who have undergone "puberty suppression." The UK Sport Councils Literature Review notes that, "In the UK, so-called 'puberty blockers' are generally not used until Tanner maturation stage 2-3 (i.e. after puberty has progressed into early sexual maturation)." (9.) While it is outside my expertise, my understanding is that current practice with regard to administration of puberty blockers is similar in the Unites States. Tanner stages 2 and 3 generally encompass an age range from 10 to 14 years old, with significant differences between individuals. Like the authors of the UK Sports Council Literature Review, I am "not aware of research" directly addressing the implications for athletic capability of the use of puberty blockers. (UK Sport Councils Literature Review at 9.) As Handelsman documents, the male advantage begins to increase rapidly–along with testosterone levels–at about age 11, or "very closely aligned to the timing of the onset of male puberty." (Handelsman 2017.) It seems likely that males who have undergone puberty suppression will

[10] This term would include testosterone and estrogens.

have physiological and performance advantages over females somewhere between those possessed by pre-pubertal boys, and those who have gone through full male puberty, with the degree of advantage in individual cases depending on that individual's development and the timing of the start of puberty blockade.

111. Tack et al. (2018) observed that in 21 transgender-identifying biological males, administration of antiandrogens for 5-31 months (commencing at 16.3 ± 1.21 years of age), resulted in nearly, but not completely, halting of normal age-related *increases* in muscle strength. Importantly, muscle strength did not decrease after administration of antiandrogens. Rather, despite antiandrogens, these individuals retained higher muscle mass, lower percent body fat, higher body mass, higher body height, and higher grip strength than comparable girls of the same age. (Supplemental tables).

112. Klaver et al. (2018 at 256) demonstrated that the use of puberty blockers did not eliminate the differences in lean body mass between biological male and female teenagers. Subsequent use of puberty blockers combined with cross-sex hormone use (in the same subjects) still did not eliminate the differences in lean body mass between biological male and female teenagers. Furthermore, by 22 years of age, the use of puberty blockers, and then puberty blockers combined with cross sex hormones, and then cross hormone therapy alone for over 8 total years of treatment still had not eliminated the difference in lean body mass between biological males and females.

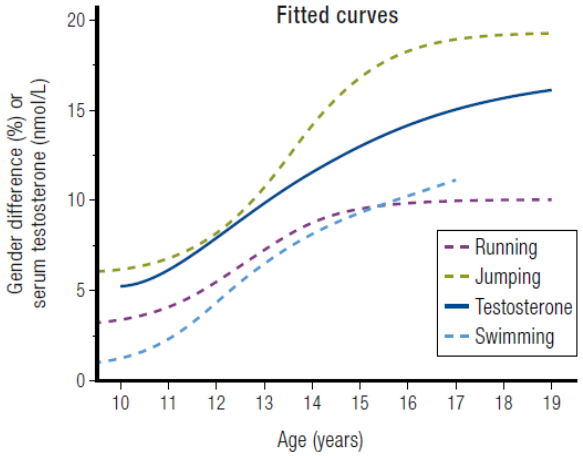
113. The effects of puberty blockers on growth and development, including muscle mass, fat mass, or other factors that influence athletic performance, have been minimally researched. Indeed, Klaver et al. (2018) is the only published research that I am aware of that has evaluated the use of puberty blockers on body composition. As stated by Roberts and Carswell (2021), "No published studies have fully characterized the impact of [puberty blockers on] final adult height or current height in an actively growing TGD youth." (1680). Likewise, "[n]o published literature provides guidance on how to best predict the final adult height for TGD youth receiving GnRHa and gender- affirming hormonal treatment." (1681). Thus, the effect of prescribing puberty blockers to a male child before the onset of puberty on the physical components of athletic performance is largely unknown. There is not any scientific evidence that such treatment eliminates the pre-existing performance advantages that prepubertal males have over prepubertal females.

B. The rapid increase in testosterone across male puberty drives characteristic male physiological changes and the increasing performance advantages.

114. While boys exhibit some performance advantage even before puberty, it is both true and well known to common experience that the male advantage

increases rapidly, and becomes much larger, as boys undergo puberty and become men. Empirically, this can be seen by contrasting the modest advantages reviewed immediately above against the large performance advantages enjoyed by men that I have detailed in Section II.

115. Multiple studies (along with common observation) document that the male performance advantage begins to increase during the early years of puberty, and then increases rapidly across the middle years of puberty (about ages 12-16). (Tønnessen 2015; Handelsman 2018 at 812-813.) Since it is well known that testosterone levels increase by more than an order of magnitude in boys across puberty, it is unsurprising that Handelsman finds that these increases in male performance advantage correlate to increasing testosterone levels, as presented in his chart reproduced below. (Handelsman 2018 at 812-13.)



116. Handelsman further finds that certain characteristic male changes including boys' increase in muscle mass do not begin at all until "circulating testosterone concentrations rise into the range of males at mid-puberty, which are higher than in women at any age." (Handelsman 2018 at 810.)

117. Knox et al. (2019) agree that "[i]t is well recognised that testosterone contributes to physiological factors including body composition, skeletal structure, and the cardiovascular and respiratory systems across the life span, with significant influence during the pubertal period. These physiological factors underpin strength, speed, and recovery with all three elements required to be competitive in almost all sports." (Knox 2019 at 397.) "High testosterone levels and prior male physiology provide an all-purpose benefit, and a substantial advantage. As the IAAF says, 'To the best of our knowledge, there is no other genetic or biological trait encountered in female athletics that confers such a huge performance advantage.'" (Knox 2019 at 399.)

118. However, the undisputed fact that high (that is, normal male) levels of testosterone drive the characteristically male physiological changes that occur across male puberty does not at all imply that artificially *depressing* testosterone levels after those changes occur will reverse all or most of those changes so as to eliminate the male athletic advantage. This is an empirical question. As it turns out, the answer is that while some normal male characteristics can be changed by means of testosterone suppression, others cannot be, and all the reliable evidence indicates that males retain large athletic advantages even after long-term testosterone suppression.

V. The available evidence shows that suppression of testosterone in a male after puberty has occurred does not substantially eliminate the male athletic advantage.

119. The 2011 "NCAA Policy on Transgender Student-Athlete Participation" requires only that males who identify as transgender be on unspecified and unquantified "testosterone suppression treatment" for "one calendar year" prior to competing in women's events. In supposed justification of this policy, the NCAA's Office of Inclusion asserts that, "It is also important to know that any strength and endurance advantages a transgender woman arguably may have as a result of her prior testosterone levels dissipate after about one year of estrogen or testosterone-suppression therapy." (NCAA 2011 at 8.)

120. Similarly, writing in 2018, Handelsman et al. could speculate that even though some male advantages established during puberty are "fixed and irreversible (bone size)," "[t]he limited available prospective evidence . . . suggests that the advantageous increases in muscle and hemoglobin due to male circulating testosterone concentrations are induced or reversed during the first 12 months." (Handelsman 2018 at 824.)

121. But these assertions or hypotheses of the NCAA and Handelsman are now strongly contradicted by the available science. In this section, I examine what is known about whether suppression of testosterone in males can eliminate the male physiological and performance advantages over females.

A. Empirical studies find that males retain a strong performance advantage even after lengthy testosterone suppression.

122. As my review in Section II indicates, a very large body of literature documents the large performance advantage enjoyed by males across a wide range of athletics. To date, only a limited number of studies have directly measured the effect of testosterone suppression and the administration of female hormones on the athletic performance of males. These studies report that testosterone suppression for a full year (and in some cases much longer) does not come close to eliminating

male advantage in strength (hand grip, leg strength, and arm strength) or running speed.

Hand Grip Strength

123. As I have noted, hand grip strength is a well-accepted proxy for general strength. Multiple separate studies, from separate groups, report that males retain a large advantage in hand strength even after testosterone suppression to female levels.

124. In a longitudinal study, Van Caenegem et al. reported that males who underwent standard testosterone suppression protocols lost only 7% hand strength after 12 months of treatment, and only a cumulative 9% after two years. (Van Caenegem 2015 at 42.) As I note above, on average men exhibit in the neighborhood of 60% greater hand grip strength than women, so these small decreases do not remotely eliminate that advantage. Van Caenegem et al. document that their sample of males who elected testosterone suppression began with less strength than a control male population. Nevertheless, after one year of suppression, their study population still had hand grip only 21% less than the control male population, and thus still far higher than a female population. (Van Caenegem 2015 at 42.)

125. Scharff et al. (2019) measured grip strength in a large cohort of male-to-female subjects from before the start of hormone therapy through one year of hormone therapy. The hormone therapy included suppression of testosterone to less than 2 nml/L "in the majority of the transwomen," (1024), as well as administration of estradiol (1021). These researchers observed a small decrease in grip strength in these subjects over that time (Fig. 2), but mean grip strength of this group remained far higher than mean grip strength of females—specifically, "After 12 months, the median grip strength of transwomen [male-to-female subjects] still falls in the 95th percentile for age-matched females." (1026).

126. Still a third longitudinal study, looking at teen males undergoing testosterone suppression, "noted no change in grip strength after hormonal treatment (average duration 11 months) of 21 transgender girls." (Hilton 2021 at 207, summarizing Tack 2018.)

127. In a fourth study, Lapauw et al. (2008) looked at the extreme case of testosterone suppression by studying a population of 23 biologically male individuals who had undergone at least two years of testosterone suppression, followed by sex reassignment surgery that included "orchidectomy" (that is, surgical castration), and then at least an additional three years before the study date. Comparing this group against a control of age- and height-matched healthy males, the researchers found that the individuals who had gone through testosterone suppression and then surgical castration had an average hand grip (41 kg) that was

24% weaker than the control group of healthy males. But this remains at least 25% *higher* than the average hand-grip strength of biological females as measured by Bohannon et al. (2019).

128. Summarizing these and a few other studies measuring strength loss (in most cases based on hand grip) following testosterone suppression, Harper et al. (2021) conclude that "strength loss with 12 months of [testosterone suppression] . . . ranged from non-significant to 7%. . . . [T]he small decrease in strength in transwomen after 12-36 months of [testosterone suppression] suggests that transwomen likely retain a strength advantage over cisgender women." (Hilton 2021 at 870.)

Arm Strength

129. Lapauw et al. (2008) found that 3 years after surgical castration, preceded by at least two years of testosterone suppression, biologically male subjects had 33% less bicep strength than healthy male controls. (Lapauw (2008) at 1018.) Given that healthy men exhibit between 89% and 109% greater arm strength than healthy women, this leaves a very large residual arm strength advantage over biological women.

130. Roberts et al. have recently published an interesting longitudinal study, one arm of which considered biological males who began testosterone suppression and cross-sex hormones while serving in the United States Air Force. (Roberts 2020.) One measured performance criterion was pushups per minute, which, while not exclusively, primarily tests arm strength under repetition. *Before* treatment, the biological male study subjects who underwent testosterone suppression could do 45% more pushups per minute than the average for all Air Force women under the age of 30 (47.3 vs. 32.5). *After* between one and two years of testosterone suppression, this group could still do 33% more pushups per minute. (Table 4.) Further, the body weight of the study group did not decline at all after one to two years of testosterone suppression (in fact rose slightly) (Table 3), and was approximately 24 pounds (11.0 kg) higher than the average for Air Force women under the age of 30. (Roberts 2020 at 3.) This means that the individuals who had undergone at least one year of testosterone suppression were not only doing 1/3 more pushups per minute, but were lifting significantly more weight with each pushup.

131. After two years of testosterone suppression, the study sample in Roberts et al. was only able to do 6% more pushups per minute than the Air Force female average. But their weight remained unchanged from their pre-treatment starting point, and thus about 24 pounds higher than the Air Force female average. As Roberts et al. explain, "as a group, transwomen weigh more than CW [cis-women]. Thus, transwomen will have a higher power output than CW when

performing an equivalent number of push-ups. Therefore, our study may underestimate the advantage in strength that transwomen have over CW." (Roberts 2020 at 4.)

Leg Strength

132. Wiik et al. (2020), in a longitudinal study that tracked 11 males from the start of testosterone suppression through 12 months after treatment initiation, found that isometric strength levels measured at the knee "were maintained over the [study period]."[11] (808) "At T12 [the conclusion of the one-year study], the absolute levels of strength and muscle volume were greater in [male-to-female subjects] than in . . . CW [women who had not undergone any hormonal therapy]." (Wiik 2020 at 808.) In fact, Wiik et al. reported that "muscle strength after 12 months of testosterone suppression was comparable to baseline strength. As a result, transgender women remained about 50% stronger than . . . a reference group of females." (Hilton 2021 at 207, summarizing Wiik 2020.)

133. Lapauw et al. (2008) found that 3 years after surgical castration, preceded by at least two years of testosterone suppression, subjects had peak knee torque only 25% lower than healthy male controls. (Lapauw 2008 at 1018.) Again, given that healthy males exhibit 54% greater maximum knee torque than healthy females, this leaves these individuals with a large average strength advantage over females even years after sex reassignment surgery.

Running speed

134. The most striking finding of the recent Roberts et al. study concerned running speed over a 1.5 mile distance–a distance that tests midrange endurance. Before suppression, the MtF study group ran 21% faster than the Air Force female average. After at least 2 year of testosterone suppression, these subjects still ran 12% faster than the Air Force female average. (Roberts 2020 Table 4.)

135. The specific experience of the well-known case of NCAA athlete Cece Telfer is consistent with the more statistically meaningful results of Roberts et al., further illustrating that male-to-female transgender treatment does not negate the inherent athletic performance advantages of a post-pubertal male. In 2016 and 2017 Cece Telfer competed as Craig Telfer on the Franklin Pierce University men's track team, being ranked 200th and 390th (respectively) against other NCAA Division 2 men. "Craig" Telfer did not qualify for the National Championships in any events. Telfer did not compete in the 2018 season while undergoing testosterone

[11] Isometric strength measures muscular force production for a given amount of time at a specific joint angle but with no joint movement.

suppression (per NCAA policy). In 2019 Cece Telfer competed on the Franklin Pierce University *women's* team, qualified for the NCAA Division 2 Track and Field National Championships, and placed 1st in the women's 400 meter hurdles and placed third in the women's 100 meter hurdles. (For examples of the media coverage of this please see https://www.washingtontimes.com/news/2019/jun/3/cece-telfer-franklin-pierce-transgenderhurdler-wi/ last accessed May 29, 2020. https://www.newshub.co.nz/home/sport/2019/06/athletics-transgender-woman-cece-telfer-whopreviously-competed-as-a-man-wins-ncaa-track-championship.html (last accessed May 29, 2020.)

136. The table below shows the best collegiate performance times from the combined 2015 and 2016 seasons for Cece Telfer when competing as a man in men's events, and the best collegiate performance times from the 2019 season when competing as a woman in women's events. Comparing the times for the running events (in which male and female athletes run the same distance) there is no statistical difference between Telfer's "before and after" times. Calculating the difference in time between the male and female times, Telfer performed an average of 0.22% *faster* as a female. (Comparing the performance for the hurdle events (marked with H) is of questionable validity due to differences between men's and women's events in hurdle heights and spacing, and distance for the 110m vs. 100 m.) While this is simply one example, and does not represent a controlled experimental analysis, this information provides some evidence that male-to-female transgender treatment does not negate the inherent athletic performance advantages of a postpubertal male. (These times were obtained from https://www.tfrrs.org/athletes/6994616/Franklin_Pierce/CeCe_Telfer.html and https://www.tfrrs.org/athletes/5108308.html, last accessed May 29, 2020).

As Craig Telfer (male athlete)		**As Cece Telfer (female athlete)**	
Event	Time (seconds)	Event	Time (seconds)
55	7.01	55	7.02
60	7.67	60	7.63
100	12.17	100	12.24
200	24.03	200	24.30
400	55.77	400	54.41
55 H †	7.98	55 H†	7.91
60 H †	8.52	60 H†	8.33
110 H†	15.17	100 H†	13.41*
400 H‡	57.34	400 H‡	57.53**

* women's 3rd place, NCAA Division 2 National Championships
** women's 1st place, NCAA Division 2 National Championships
† men's hurdle height is 42 inches with differences in hurdle spacing between men and women
‡ men's hurdle height is 36 inches, women's height is 30 inches with the same spacing between hurdles

137. Similarly, University of Pennsylvania swimmer Lia Thomas began competing in the women's division in the fall of 2021, after previously competing for U. Penn. in the men's division. Thomas has promptly set school, pool, and/or league women's records in 200 yard freestyle, 500 yard freestyle, and 1650 yard freestyle competitions, beating the nearest female in the 1650 yard by an unheard-of 38 seconds.

138. In a pre-peer review article, Senefeld, Coleman, Hunter, and Joyner (doi: https://doi.org/10.1101/2021.12.28.21268483, accessed January 12, 2022) "compared the gender-related differences in performance of a transgender swimmer who competed in both the male and female NCAA (collegiate) categories to the sex-related differences in performance of world and national class swimmers" and observed that this athlete [presumably Lia Thomas based on performance times and the timing of this article] was unranked in 2018-2019 in the 100-yard, ranked 551st in the 200-yard, 65th in the 500-yard 32nd in the 1650-yards men's freestyle. After following the NCAA protocol for testosterone suppression and competing as a woman in 2021-2022, this swimmer was ranked 94th in the 100-yard, 1st in the 200-yard, 1st in the 500-yard, and 6th in the 1650-yard women's freestyle. The performance times swimming as a female, when compared to swimming as a male, were 4.6% slower in the 100-yard, 2.6% slower in the 200-yard, 5.6% slower in the 500-yard, and 6.8% slower in the 1650-yard events than when swimming as a male. *It is important to note that these are mid-season race times and do not represent season best performance times or in a championship event where athletes often set their personal record times*. The authors concluded "…that for middle distance events (100, 200 and 400m or their imperial equivalents) lasting between about one and five minutes, the decrements in performance of the transgender woman swimmer are less than expected on the basis of a comparison of a large cohort of world and national class performances by female and male swimmers" and "it is possible that the relative improvements in this swimmer's rankings in the women's category relative to the men's category are due to legacy effects of testosterone on a number of physiological factors that can influence athletic performance."

139. Harper (2015) has often been cited as "proving" that testosterone suppression eliminates male advantage. And indeed, hedged with many disclaimers, the author in that article does more or less make that claim with respect to "distance races," while emphasizing that "the author makes no claims as to the equality of performances, pre and post gender transition, in any other sport." (Harper 2015 at 8.) However, Harper (2015) is in effect a collection of unverified anecdotes, not science. It is built around self-reported race times from just eight self-selected transgender runners, recruited "mostly" online. How and on what websites the subjects were recruited is not disclosed, nor is anything said about how those not recruited online were recruited. Thus, there is no information to tell us whether these eight runners could in any way be representative, and the

recruitment pools and methodology, which could bear on ideological bias in their self-reports, is not disclosed.

140. Further, the self-reported race times relied on by Harper (2015) *span 29 years*. It is well known that self-reported data, particularly concerning emotionally or ideologically fraught topics, is unreliable, and likewise that memory of distant events is unreliable. Whether the subjects were responding from memory or from written records, and if so what records, is not disclosed, and does not appear to be known to the author. For six of the subjects, the author claims to have been able to verify "approximately half" of the self-reported times. Which scores these are is not disclosed. The other two subjects responded only anonymously, so nothing about their claims could be or was verified. In short, neither the author nor the reader knows whether the supposed "facts" on which the paper's analysis is based are true.

141. Even if we could accept them at face value, the data are largely meaningless. Only two of the eight study subjects reported (undefined) "stable training patterns," and even with consistent training, athletic performance generally declines with age. As a result, when the few data points span 29 years, it is not possible to attribute declines in performance to asserted testosterone suppression. Further, distance running is usually not on a track, and race times vary significantly depending on the course and the weather. Only one reporting subject who claimed a "stable training pattern" reported "before and after" times on the same course within three years' time," which the author acknowledges would "represent the best comparison points."

142. Harper (2015) to some extent acknowledges its profound methodological flaws, but seeks to excuse them by the difficulty of breaking new ground. The author states that, "The first problem is how to formulate a study to create a meaningful measurement of athletic performance, both before and after testosterone suppression. No methodology has been previously devised to make meaningful measurements." (2) This statement was not accurate at the time of publication, as there are innumerable publications with validated methodology for comparing physical fitness and/or athletic performance between people of different ages, sexes, and before and after medical treatment, any of which could easily have been used with minimal or no adaptation for the purposes of this study. Indeed, well before the publication of Harper (2015), several authors that I have cited in this review had performed and published disciplined and methodologically reliable studies of physical performance and physiological attributes "before and after" testosterone suppression.

143. More recently, and to her credit, Harper has acknowledged the finding of Roberts (2020) regarding the durable male advantage in running speed in the 1.5 mile distance, even after two years of testosterone suppression. She joins with co-

authors in acknowledging that this study of individuals who (due to Air Force physical fitness requirements) "could at least be considered exercise trained," agrees that Roberts' data shows that "transwomen ran significantly faster during the 1.5 mile fitness test than ciswomen," and declares that this result is "consistent with the findings of the current review in untrained transgender individuals" that even 30 months of testosterone suppression does not eliminate all male advantages "associated with muscle endurance and performance." (Harper 2021 at 8.) The Harper (2021) authors conclude overall "that strength may be well preserved in transwomen during the first 3 years of hormone therapy," and that [w]hether transgender and cisgender women can engage in meaningful sport [in competition with each other], even after [testosterone suppression], is a highly debated question." (Harper 2021 at 1, 8.)

144. Higerd (2021) "[a]ssess[ed] the probability of a girls' champion being biologically male" by evaluating 920,11 American high school track and field performances available through the track and field database Athletic.net in five states (CA, FL, MN, NY, WA), over three years (2017 – 2019),in eight events; high jump, long jump, 100M, 200M, 400M, 800M, 1600M, and 3200M and estimated that "there is a simulated 81%-98% probability of transgender dominance occurring in the female track and field event" and further concluded that "in the majority of cases, the entire podium (top of the state) would be MTF [transgender athletes]" (at xii).

B. Testosterone suppression does not reverse important male physiological advantages.

145. We see that, once a male has gone through male puberty, later testosterone suppression (or even castration) leaves large strength and performance advantages over females in place. It is not surprising that this is so. What is now a fairly extensive body of literature has documented that many of the specific male physiological advantages that I reviewed in Section II are not reversed by testosterone suppression after puberty, or are reduced only modestly, leaving a large advantage over female norms still in place.

146. Handelsman has well documented that the large increases in physiological and performance advantages characteristic of men develop in tandem with, and are likely driven by, the rapid and large increases in circulating testosterone levels that males experience across puberty, or generally between the ages of about 12 through 18. (Handelsman 2018.) Some have misinterpreted Handelsman as suggesting that all of those advantages are and remain entirely dependent–on an ongoing basis–on *current* circulating testosterone levels. This is a misreading of Handelsman, who makes no such claim. As the studies reviewed above demonstrate, it is also empirically false with respect to multiple measures of

performance. Indeed, Handelsman himself, referring to the Roberts et al. (2020) study which I describe below, has recently written that "transwomen treated with estrogens after completing male puberty experienced only minimal declines in physical performance over 12 months, substantially surpassing average female performance for up to 8 years." (Handelsman 2020.)

147. As to individual physiological advantages, the more accurate and more complicated reality is reflected in a statement titled "The Role of Testosterone in Athletic Performance," published in 2019 by several dozen sports medicine experts and physicians from many top medical schools and hospitals in the U.S. and around the world. (Levine et al. 2019.) This expert group concurs with Handelsman regarding the importance of testosterone to the male advantage, but recognizes that those advantages depend not only on *current* circulating testosterone levels in the individual, but on the "exposure in biological males to much higher levels of testosterone during growth, development, and throughout the athletic career." (*Emphasis added*.) In other words, both past and current circulating testosterone levels affect physiology and athletic capability.

148. Available research enables us to sort out, in some detail, which specific physiological advantages are immutable once they occur, which can be reversed only in part, and which appear to be highly responsive to later hormonal manipulation. The bottom line is that very few of the male physiological advantages I have reviewed in Section II above are largely reversible by testosterone suppression once an individual has passed through male puberty.

Skeletal Configuration

149. It is obvious that some of the physiological changes that occur during "growth and development" across puberty cannot be reversed. Some of these irreversible physiological changes are quite evident in photographs that have recently appeared in the news of transgender competitors in female events. These include skeletal configuration advantages including:

- Longer and larger bones that give height, weight, and leverage advantages to men;
- More advantageous hip shape and configuration as compared to women.

Cardiovascular Advantages

150. Developmental changes for which there is no apparent means of reversal, and no literature suggesting reversibility, also include multiple

contributors to the male cardiovascular advantage, including diaphragm placement, lung and trachea size, and heart size and therefore pumping capacity.[12]

151. On the other hand, the evidence is mixed as to hemoglobin concentration, which as discussed above is a contributing factor to $V0_2$ max. Harper (2021) surveyed the literature and found that "Nine studies reported the levels of Hgb [hemoglobin] or HCT [red blood cell count] in transwomen before and after [testosterone suppression], from a minimum of three to a maximum of 36 months post hormone therapy. Eight of these studies. . . found that hormone therapy led to a significant (4.6%–14.0%) decrease in Hgb/HCT ($p<0.01$), while one study found no significant difference after 6 months," but only one of those eight studies returned results at the generally accepted 95% confidence level. (Harper 2021 at 5-6 and Table 5.)

152. I have not found any study of the effect of testosterone suppression on the male advantage in mitochondrial biogenesis.

Muscle mass

153. Multiple studies have found that muscle mass decreases modestly or not at all in response to testosterone suppression. Knox et al. report that "healthy young men did not lose significant muscle mass (or power) when their circulating testosterone levels were reduced to 8.8 nmol/L (lower than the 2015 IOC guideline of 10 nmol/L) for 20 weeks." (Knox 2019 at 398.) Gooren found that "[i]n spite of muscle surface area reduction induced by androgen deprivation, after 1 year the mean muscle surface area in male-to- female transsexuals remained significantly greater than in untreated female-to-male transsexuals." (Gooren 2011 at 653.) An earlier study by Gooren found that after one year of testosterone suppression, muscle mass at the thigh was reduced by only about 10%, exhibited "no further reduction after 3 years of hormones," and "remained significantly greater" than in his sample of untreated women. (Gooren 2004 at 426-427.) Van Caenegem et al. found that muscle cross section in the calf and forearm decreased only trivially (4% and 1% respectively) after two years of testosterone suppression. (Van Caenegem 2015 Table 4.)

154. Taking measurements one month after start of testosterone suppression in male-to-female (non-athlete) subjects, and again 3 and 11 months after start of feminizing hormone replacement therapy in these subjects, Wiik et al.

---

[12] "[H]ormone therapy will not alter … lung volume or heart size of the transwoman athlete, especially if [that athlete] transitions postpuberty, so natural advantages including joint articulation, stroke volume and maximal oxygen uptake will be maintained." (Knox 2019 at 398.)

found that total lean tissue (i.e. primarily muscle) did not decrease significantly across the entire period. Indeed, "some of the [subjects] did not lose any muscle mass at all." (Wiik 2020 at 812.) And even though they observed a small decrease in thigh muscle mass, they found that isometric strength levels measured at the knee "were maintained over the [study period]." (808) "At T12 [the conclusion of the one-year study], the absolute levels of strength and muscle volume were greater in [male-to-female subjects] than in [female-to-male subjects] and CW [women who had not undergone any hormonal therapy]." (808)

155. Hilton & Lundberg summarize an extensive survey of the literature as follows:

> "12 longitudinal studies have examined the effects of testosterone suppression on lean body mass or muscle size in transgender women. The collective evidence from these studies suggests that 12 months, which is the most commonly examined intervention period, of testosterone suppression to female typical reference levels results in a modest (approximately− 5%) loss of lean body mass or muscle size. . . .
>
> "Thus, given the large baseline differences in muscle mass between males and females (Table 1; approximately 40%), the reduction achieved by 12 months of testosterone suppression can reasonably be assessed as small relative to the initial superior mass. We, therefore, conclude that the muscle mass advantage males possess over females, and the performance implications thereof, are not removed by the currently studied durations (4 months, 1, 2 and 3 years) of testosterone suppression in transgender women. (Hilton 2021 at 205-207.)

156. When we recall that "women have 50% to 60% of men's upper arm muscle cross-sectional area and 65% to 70% of men's thigh muscle cross-sectional area" (Handelsman 2018 at 812), it is clear that Hilton's conclusion is correct. In other words, biologically male subjects possess substantially larger muscles than biologically female subjects after undergoing a year or even three years of testosterone suppression.

157. I note that outside the context of transgender athletes, the testosterone-driven increase in muscle mass and strength enjoyed by these male-to-female subjects would constitute a disqualifying doping violation under all league anti-doping rules with which I am familiar.

C. Responsible voices internationally are increasingly recognizing that suppression of testosterone in a male after puberty has occurred does not substantially reverse the male athletic advantage.

158. The previous very permissive NCAA policy governing transgender participation in women's collegiate athletics was adopted in 2011, and the previous IOC guidelines were adopted in 2015. At those dates, much of the scientific analysis of the actual impact of testosterone suppression had not yet been performed, much less any wider synthesis of that science. In fact, a series of important peer-reviewed studies and literature reviews have been published only very recently, since I prepared my first paper on this topic, in early 2020.

159. These new scientific publications reflect a remarkably consistent consensus: once an individual has gone through male puberty, testosterone suppression does not substantially eliminate the physiological and performance advantages that that individual enjoys over female competitors.

160. Importantly, I have found no peer-reviewed scientific paper, nor any respected scientific voice, that is now asserting the contrary–that is, that testosterone suppression can eliminate or even largely eliminate the male biological advantage once puberty has occurred.

161. I excerpt the key conclusions from important recent peer-reviewed papers below.

162. Roberts 2020: "In this study, we confirmed that . . . the pretreatment differences between transgender and cis gender women persist beyond the 12-month time requirement currently being proposed for athletic competition by the World Athletics and the IOC." (6)

163. Wiik 2020: The muscular and strength changes in males undergoing testosterone suppression "were modest. The question of when it is fair to permit a transgender woman to compete in sport in line with her experienced gender identity is challenging." (812)

164. Harper 2021: "[V]alues for strength, LBM [lean body mass], and muscle area in transwomen remain above those of cisgender women, even after 36 months of hormone therapy." (1)

165. Hilton & Lundberg 2021: "evidence for loss of the male performance advantage, established by testosterone at puberty and translating in elite athletes to a 10–50% performance advantage, is lacking. . . . These data significantly

undermine the delivery of fairness and safety presumed by the criteria set out in transgender inclusion policies . . .” (211)

166. Hamilton et al. 2020, “Response to the United Nations Human Rights Council’s Report on Race and Gender Discrimination in Sport: An Expression of Concern and a Call to Prioritize Research”: “There is growing support for the idea that development influenced by high testosterone levels may result in retained anatomical and physiological advantages . . . . If a biologically male athlete self-identifies as a female, legitimately with a diagnosis of gender dysphoria or illegitimately to win medals, the athlete already possesses a physiological advantage that undermines fairness and safety. This is not equitable, nor consistent with the fundamental principles of the Olympic Charter.”

167. Hamilton et al. 2021, “Consensus Statement of the Fédération Internationale de Médecine du Sport” (International Federation of Sports Medicine, or FIMS), signed by more than 60 sports medicine experts from prestigious institutions around the world: The available studies “make it difficult to suggest that the athletic capabilities of transwomen individuals undergoing HRT or GAS are comparable to those of cisgender women.” The findings of Roberts et al. “question the required testosterone suppression time of 12 months for transwomen to be eligible to compete in women’s sport, as most advantages over ciswomen were not negated after 12 months of HRT.”

168. Outside the forum of peer-reviewed journals, respected voices in sport are reaching the same conclusion.

169. The **Women’s Sports Policy Working Group** identifies among its members and “supporters” many women Olympic medalists, former women’s tennis champion and LGBTQ activist Martina Navratilova, Professor Doriane Coleman, a former All-American women’s track competitor, transgender athletes Joanna Harper and Dr. Renee Richards, and many other leaders in women’s sports and civil rights. I have referenced other published work of Joanna Harper and Professor Coleman. In early 2021 the Women’s Sports Policy Working Group published a “Briefing Book” on the issue of transgender participation in women’s sports,[13] in which they reviewed largely the same body of literature I have reviewed above, and analyzed the implications of that science for fairness and safety in women’s sports.

170. Among other things, the Women’s Sports Policy Working Group concluded:

[13] https://womenssportspolicy.org/wp-content/uploads/2021/02/Congressional-Briefing-WSPWG-Transgender-Women-Sports-2.27.21.pdf

- "[T]he evidence is increasingly clear that hormones do not eliminate the legacy advantages associated with male physical development" (8) due to "the considerable size and strength advantages that remain even after hormone treatments or surgical procedures." (17)

- "[T]here is convincing evidence that, depending on the task, skill, sport, or event, trans women maintain male sex-linked (legacy) advantages even after a year on standard gender-affirming hormone treatment." (26, citing Roberts 2020.)

- "[S]everal peer-reviewed studies, including one based on data from the U.S. military, have confirmed that trans women retain their male sex-linked advantages even after a year on gender affirming hormones. . . . Because of these retained advantages, USA Powerlifting and World Rugby have recently concluded that it isn't possible fairly and safely to include trans women in women's competition." (32)

171. As has been widely reported, in 2020, after an extensive scientific consultation process, the **World Rugby** organization issued its Transgender Guidelines, finding that it would not be consistent with fairness or safety to permit biological males to compete in World Rugby women's matches, no matter what hormonal or surgical procedures they might have undergone. Based on their review of the science, World Rugby concluded:

- "Current policies regulating the inclusion of transgender women in sport are based on the premise that reducing testosterone to levels found in biological females is sufficient to remove many of the biologically-based performance advantages described above. However, peer-reviewed evidence suggests that this is not the case."

- "Longitudinal research studies on the effect of reducing testosterone to female levels for periods of 12 months or more do not support the contention that variables such as mass, lean mass and strength are altered meaningfully in comparison to the original male-female differences in these variables. The lowering of testosterone removes only a small proportion of the documented biological differences, with large, retained advantages in these physiological attributes, with the safety and performance implications described previously."

- ". . . given the size of the biological differences prior to testosterone suppression, this comparatively small effect of testosterone reduction allows substantial and meaningful differences to remain. This has significant implications for the risk of injury . . . ."

- " . . . bone mass is typically maintained in transgender women over the course of at least 24 months of testosterone suppression, ... Height and other skeletal measurements such as bone length and hip width have also not been shown to change with testosterone suppression, and nor is there any plausible biological mechanism by which this might occur, and so sporting advantages due to skeletal differences between males and females appear unlikely to change with testosterone reduction.

172. In September 2021 the government-commissioned Sports Councils of the United Kingdom and its subsidiary parts (the five Sports Councils responsible for supporting and investing in sport across England, Wales, Scotland and Northern Ireland) issued a formal "Guidance for Transgender Inclusion in Domestic Sport" (UK Sport Councils 2021), following an extensive consultation process, and a commissioned "International Research Literature Review" prepared by the Carbmill Consulting group (UK Sport Literature Review 2021). The UK Sport Literature Review identified largely the same relevant literature that I review in this paper, characterizes that literature consistently with my own reading and description, and based on that science reaches conclusions similar to mine.

173. The UK Sport Literature Review 2021 concluded:

- "Sexual dimorphism in relation to sport is significant and the most important determinant of sporting capacity. The challenge to sporting bodies is most evident in the inclusion of transgender people in female sport." "[The] evidence suggests that parity in physical performance in relation to gender-affected sport cannot be achieved for transgender people in female sport through testosterone suppression. Theoretical estimation in contact and collision sport indicate injury risk is likely to be increased for female competitors." (10)

- "From the synthesis of current research, the understanding is that testosterone suppression for the mandated one year before competition will result in little or no change to the anatomical differences between the sexes, and a more complete reversal of some acute phase metabolic pathways such as haemoglobin levels although the impact on running performance appears limited, and a modest change in muscle mass and strength: The average of around 5% loss of muscle mass and strength will not reverse the average 40-50% difference in strength that typically exists between the two sexes." (7)

- "These findings are at odds with the accepted intention of current policy in sport, in which twelve months of testosterone suppression is

expected to create equivalence between transgender women and females." (7)

174. Taking into account the science detailed in the UK Sport Literature Review 2021, the UK Sports Councils have concluded:

- "[T]he latest research, evidence and studies made clear that there are retained differences in strength, stamina and physique between the average woman compared with the average transgender woman or non-binary person registered male at birth, with or without testosterone suppression." (3)

- "Competitive fairness cannot be reconciled with self-identification into the female category in gender-affected sport." (7)

- "As a result of what the review found, the Guidance concludes that the inclusion of transgender people into female sport cannot be balanced regarding transgender inclusion, fairness and safety in gender-affected sport where there is meaningful competition. This is due to retained differences in strength, stamina and physique between the average woman compared with the average transgender woman or non-binary person assigned male at birth, with or without testosterone suppression." (6)

- "Based upon current evidence, testosterone suppression is unlikely to guarantee fairness between transgender women and natal females in gender-affected sports. . . . Transgender women are on average likely to retain physical advantage in terms of physique, stamina, and strength. Such physical differences will also impact safety parameters in sports which are combat, collision or contact in nature." (7)

175. On January 15, 2022 the American Swimming Coaches Association (ASCA) issued a statement stating, "The American Swimming Coaches Association urges the NCAA and all governing bodies to work quickly to update their policies and rules to maintain fair competition in the women's category of swimming. ASCA supports following all available science and evidenced-based research in setting the new policies, and we strongly advocate for more research to be conducted" and further stated "The current NCAA policy regarding when transgender females can compete in the women's category can be unfair to cisgender females and needs to be reviewed and changed in a transparent manner." (https://swimswam.com/asca-issues-statement-calling-for-ncaa-to-review-transgender-rules/; Accessed January 16, 2022.)

176. On January 19, 2022, the NCAA Board of Governors approved a change to the policy on transgender inclusion in sport and stated that "…the updated NCAA policy calls for transgender participation for each sport to be determined by the policy for the national governing body of that sport, subject to ongoing review and recommendation by the NCAA Committee on Competitive Safeguards and Medical Aspects of Sports to the Board of Governors. If there is no N[ational]G[overning]B[ody] policy for a sport, that sport's international federation policy would be followed. If there is no international federation policy, previously established IOC policy criteria would be followed" (https://www.ncaa.org/news/2022/1/19/media-center-board-of-governors-updates-transgender-participation-policy.aspx; Accessed January 20, 2022.)

177. On February 1, 2022, because "…a competitive difference in the male and female categories and the disadvantages this presents in elite head-to-head competition … supported by statistical data that shows that the top-ranked female in 2021, on average, would be ranked 536th across all short course yards (25 yards) male events in the country and 326th across all long course meters (50 meters) male events in the country, among USA Swimming members," USA Swimming released its Athlete Inclusion, Competitive Equity and Eligibility Policy. The policy is intended to "provide a level-playing field for elite cisgender women, and to mitigate the advantages associated with male puberty and physiology." (USA Swimming Releases Athlete Inclusion, Competitive Equity and Eligibility Policy, available at https://www.usaswimming.org/news/2022/02/01/usa-swimming-releases-athlete-inclusion-competitive-equity-and-eligibility-policy.) The policy states:

- For biologically male athletes seeking to compete in the female category in certain "elite" level events, the athlete has the burden of demonstrating to a panel of independent medical experts that:
    - "From a medical perspective, the prior physical development of the athlete as Male, as mitigated by any medical intervention, does not give the athlete a competitive advantage over the athlete's cisgender Female competitors" and
    - There is a presumption that the athlete is not eligible unless the athlete "demonstrates that the concentration of testosterone in the athlete's serum has been less than 5 nmol/L . . . continuously for a period of at least thirty-six (36) months before the date of the Application." This presumption may be rebutted "if the Panel finds, in the unique circumstances of the case, that [the athlete's prior physical development does not give the athlete a competitive advantage] notwithstanding the athlete's serum testosterone results (e.g., the athlete has a medical condition

which limits bioavailability of the athlete's free testosterone)." (USA Swimming Athlete Inclusion Procedures at 43.)

Conclusions

The research and actual observed data show the following:

- At the level of (a) elite, (b) collegiate, (c) scholastic, and (d) recreational competition, men, adolescent boys, or male children, have an advantage over equally gifted, aged and trained women, adolescent girls, or female children in almost all athletic events;

- Biological male physiology is the basis for the performance advantage that men, adolescent boys, or male children have over women, adolescent girls, or female children in almost all athletic events; and

- The administration of androgen inhibitors and cross-sex hormones to men or adolescent boys after the onset of male puberty does not eliminate the performance advantage that men and adolescent boys have over women and adolescent girls in almost all athletic events. Likewise, there is no published scientific evidence that the administration of puberty blockers to males before puberty eliminates the pre-existing athletic advantage that prepubertal males have over prepubertal females in almost all athletic events.

For over a decade sports governing bodies (such as the IOC and NCAA) have wrestled with the question of transgender inclusion in female sports. The previous polices implemented by these sporting bodies had an underlying "premise that reducing testosterone to levels found in biological females is sufficient to remove many of the biologically-based performance advantages." (World Rugby 2020 at 13.) Disagreements centered around what the appropriate threshold for testosterone levels must be–whether the 10nmol/liter value adopted by the IOC in 2015, or the 5nmol/liter value adopted by the IAAF.

But the science that has become available within just the last few years contradicts that premise. Instead, as the UK Sports Councils, World Rugby, the FIMS Consensus Statement, and the Women's Sports Policy Working Group have all recognized the science is now sharply "at odds with the accepted intention of current policy in sport, in which twelve months of testosterone suppression is expected to create equivalence between transgender women and females" (UK Sports Literature Review 2021 at 7), and it is now "difficult to suggest that the athletic capabilities of transwomen individuals undergoing HRT or GAS are comparable to those of cisgender women." (Hamilton, FIMS Consensus Statement 2021.) It is important to note that while the 2021 "IOC Framework on Fairness,

Inclusion, and Non-Discrimination on the Basis of Gender Identity and Sex Variations" calls for an "evidence-based approach," that Framework does not actually reference *any* of the now extensive scientific evidence relating to the physiological differences between the sexes, and the inefficacy of hormonal intervention to eliminate male advantages relevant to most sports. Instead, the IOC calls on other sporting bodies to define criteria for transgender inclusion, while demanding that such criteria simultaneously ensure fairness, safety, and inclusion for all. The recently updated NCAA policy on transgender participation also relies on other sporting bodies to establish criteria for transgender inclusion while calling for fair competition and safety.

But what we currently know tells us that these policy goals—fairness, safety, and full transgender inclusion—are irreconcilable for many or most sports. Long human experience is now joined by large numbers of research papers that document that males outperform females in muscle strength, muscular endurance, aerobic and anaerobic power output, VO_2max, running speed, swimming speed, vertical jump height, reaction time, and most other measures of physical fitness and physical performance that are essential for athletic success. The male advantages have been observed in fitness testing in children as young as 3 years old, with the male advantages increasing immensely during puberty. To ignore what we know to be true about males' athletic advantages over females, based on mere hope or speculation that cross sex hormone therapy (puberty blockers, androgen inhibitors, or cross-sex hormones) might neutralize that advantage, when the currently available evidence says it does not, is not science and is not "evidence-based" policy-making.

Because of the recent research and analysis in the general field of transgender athletics, many sports organizations have revised their policies or are in the process of doing so. As a result, there is not any universally recognized policy among sports organizations, and transgender inclusion policies are in a state of flux, likely because of the increasing awareness that the goals of fairness, safety, and full transgender inclusion are irreconcilable.

Sports have been separated by sex for the purposes of safety and fairness for a considerable number of years. The values of safety and fairness are endorsed by numerous sports bodies, including the NCAA and IOC. The existing evidence of durable physiological and performance differences based on biological sex provides a strong evidence-based rationale for keeping rules and policies for such sex-based separation in place (or implementing them as the case may be).

As set forth in detail in this report, there are physiological differences between males and females that result in males having a significant performance advantage over similarly gifted, aged, and trained females in nearly all athletic events before, during, and after puberty. There is not scientific evidence that any

amount or duration of cross sex hormone therapy (puberty blockers, androgen inhibitors, or cross-sex hormones) eliminates all physiological advantages that result in males performing better than females in nearly all athletic events. Males who have received such therapy retain sufficient male physiological traits that enhance athletic performance vis-à-vis similarly aged females and are thus, from a physiological perspective, more accurately categorized as male and not female.

.

Bibliography

Bhargava, A. et al. *Considering Sex as a Biological Variable in Basic and Clinical Studies: An Endocrine Society Scientific Statement.* Endocr Rev. 42:219-258 (2021).

Bohannon, R.W. et al., *Handgrip strength: a comparison of values obtained from the NHANES and NIH toolbox studies*. Am. J. Occ. Therapy 73(2) (March/April 2019).

Catley, M. and G.Tomkinson, *Normative health-related fitness values for children: analysis of 85,437 test results on 9-17-year-old Australians since 1985*. Br. J. Sports Med. published online October 21, 2011. Bjsm.bmj.com. Additional versions of this article were published by BJSM in 2012 and 2013, including Br. J. Sports Med. 47:98-108 (2013).

Chu, Y. et al., *Biomechanical comparison between elite female and male baseball pitchers*. J. App. Biomechanics 25:22-31 (2009).

Coleman, D.L. and W. Shreve, *Comparing athletic performances: the best elite women to boys and men*. web.law.duke.edu/sites/default/files/centers/sportslaw/comparingathleticperformances.pdf. (Accessed 06/20/21)

Coleman, D. L. et al., *Re-affirming the value of the sports exception to Title IX's general non-discrimination rule*. Duke J. of Gender and Law Policy 27(69):69-134 (2020).

Davis SM, Kaar JL, Ringham BM, Hockett CW, Glueck DH, and Dabelea D. *Sex differences in infant body composition emerge in the first 5 months of life*. J Pediatr Endocrinol Metab 32: 1235-1239 (2019).

De Miguel-Etayo, P. et al., *Physical fitness reference standards in European children: the IDEFICS study*. Int. J. Obes (Lond) 38(2):557-566 (2014).

Dogan, B., *Multiple-choice reaction and visual perception in female and male elite athletes*. J. Sports Med. and Physical Fitness 49:91-96 (2009).

Dykiert, D. and G. Der, *Sex differences in reaction time mean and intraindividual variability across the life span*. Developmental Psychology 48(5): 1262-76 (2012).

Eiberg, S. et al, *Maximum oxygen uptake and objectively measured physical activity in Danish children 6-7 years of age: the Copenhagen school child intervention study*. Br J Sports Med 39:725-30 (2005).

Fessler, D.M. et al. *Sexual dimorphism in foot length proportionate to stature*. Ann Hum Biol. 32:44-59 (2005).

Fields J. et al., *Seasonal and Longitudinal Changes in Body Composition by Sport-Position in NCAA Division I Basketball Athletes*. Sports (Basel). 22:6 (2018).

Gauthier. R. et al. The physical work capacity of Canadian children, aged 7 to 17 in 1983. A comparison with 1968. CAHPER Journal/Revue de l'ACSEPR 50:4–9 (1983).

Gershoni, M. & Pietrokovski, S. *The landscape of sex-differential transcriptome and its consequent selection in human adults*. BMC BIOL 15: 7 (2017).

Gooren, L., *The significance of testosterone for fair participation of the female sex in competitive sports*, 13 Asian J. of Andrology 653 (2011).

Gooren, L., et al., *Transsexuals and competitive sports*. Eur. J. Endocrinol. 151:425-9 (2004).

Haizlip, K.M. et al., *Sex-based differences in skeletal muscle kinetics and fiber-type composition*. PHYSIOLOGY (BETHESDA) 30: 30–39 (2015).

Hamilton, B. et al, *Integrating transwomen and female athletes with differences of sex development (DSD) into elite competition: the FIMS 2021 consensus statement*. Sports Med 2021. doi: 10.1007/s40279-021-01451-8.

Hamilton, B. et al., *Response to the United Nations Human Rights Council's report on race and gender discrimination in sport: an expression of concern and a call to prioritise research*. Sports Med 2020. doi: 10.1007/s40279-020-01380-4.

Handelsman, D.J. et al., *Circulating testosterone as the hormonal basis of sex differences in athletic performance*. Endocrine Reviews 39(5):803-829 (Oct 2018).

Handelsman, D.J., *Sex differences in athletic performance emerge coinciding with the onset of male puberty*, 87 Clinical Endocrinology 68 (2017).

Handelsman, D.J., *"Perspective,"* at https://www.healio.com/news/endocrinology/20201216/transgender-women-outpace-cisgender-women-in-athletic-tests-after-1-year-on-hormones (last accessed September 29, 2021).

Harper, J. et al., *How does hormone transition in transgender women change body composition, muscle strength and haemoglobin? Systematic review with a focus on the implications for sport participation*. Br J Sports Med 55(15):865-872 (2021).

Harper, J., *Race time for transgender athletes.* J. Sporting Cultures & Identities 6:1 (2015).

Heydari R, et al. *Y chromosome is moving out of sex determination shadow*. Cell Biosci. 12:4. (2022).

Higerd, G.A. *Assessing the Potential Transgender Impact on Girl Champions in American High School Track and Field.* Doctoral Dissertation United States Sports Academy. (2020). https://www.proquest.com/openview/65d34c1e949899aa823beecad873afae/1?pq-origsite=gscholar&cbl=18750&diss=y

Hilton, E. N. and T.R. Lundberg, *Transgender women in the female category of sport: perspectives on testosterone suppression and performance advantage.* Sports Medicine 51:199-214 (2021).

Hubal, M., H. Gordish-Dressman, P. Thompson, et al., *Variability in muscle size and strength gain after unilateral resistance training*, Med & Sci in Sports & Exercise 964 (2005).

Jain, A. et al., *A comparative study of visual and auditory reaction times on the basis of gender and physical activity levels of medical first year students.* Int J App & Basic Med Res 5:2(124-27) (May-Aug 2015).

Klaver M, et al.. *Early Hormonal Treatment Affects Body Composition and Body Shape in Young Transgender Adolescents*. J Sex Med 15: 251-260 (2018).

Knechtle, B., P. T. Nikolaidis et al., *World single age records in running from 5 km to marathon*, Frontiers in Psych 9(1) (2013).

Knox, T., L.C. Anderson, et al., *Transwomen in elite sport: scientific & ethical considerations*, 45 J. Med Ethics 395 (2019).

Lapauw, B. et al., *Body composition, volumetric and areal bone parameters in male-to-female transsexual persons.* Bone 43:1016-21 (2008).

Latorre-Roman, P. et al., *Reaction times of preschool children on the ruler drop test: a cross-sectional study with reference values.* Perceptual & Motor Skills 125(5):866-78 (2018).

Lepers, R., B. Knechtle et al., *Trends in triathlon performance: effects of sex & age*, 43 Sports Med 851 (2013).

Lesinski, M., A. Schmelcher, et al., *Maturation-, age-, and sex-specific anthropometric and physical fitness percentiles of German elite young athletes.* PLoS One. 15(8):e0237423 (2020).

Levine, B., M. Joyner et al., *The role of testosterone in athletic performance.* Available at https://web.law.duke.edu/sites/default/files/centers/sportslaw/Experts_T_Statement_2019.pdf (January 2019).

Leyk, D, W. Gorges et al., *Hand-grip strength of young men, women and highly trained female athletes*, Eur J Appl Physiol. 2007 Mar; 99(4):415-21 (2007).

Lombardo, M. and R. Deaner, *On the evolution of the sex differences in throwing: throwing as a male adaptation in humans*, Quarterly Rev of Biology 93(2):91-119 (2018).

Malina R.M., Bouchards, C., Bar-Or, O. Growth, Maturation, and Physical Activity (2nd edition). Published by Human Kinetics. 2004.

McManus, A. and N. Armstrong, *Physiology of elite young female athletes*. J Med & Sport Sci 56:23-46 (2011).

Millard-Stafford, M. et al., *Nature versus nurture: have performance gaps between men and women reached an asymptote?* Int'l J. Sports Physiol. & Performance 13:530-35 (2018).

Miller, V.M. *Why are sex and gender important to basic physiology and translational and individualized medicine?* Am J Physiol Heart Circ Physiol 306(6): H781-788, (2014).

Mormile, M. et al., *The role of gender in neuropsychological assessment in healthy adolescents*. J Sports Rehab 27:16-21 (2018).

Morris, J. et al., *Sexual dimorphism in human arm power and force: implications for sexual selection on fighting ability*. J Exp Bio 223 (2020).

National Collegiate Athletic Association, *Inclusion of transgender student-athletes*. https://ncaaorg.s3.amazonaws.com/inclusion/lgbtq/INC_TransgenderHandbook.pdf (August 2011).

Neder, J.A. et al., *Reference values for concentric knee isokinetic strength and power in nonathletic men and women from 20 to 80 years old*. J. Orth. & Sports Phys. Therapy 29(2):116-126 (1999).

Pate, R. and A. Kriska, *Physiological basis of the sex difference in cardiorespiratory endurance*. Sports Med 1:87-98 (1984).

Pocek, S. et al., *Anthropometric Characteristics and Vertical Jump Abilities by Player Position and Performance Level of Junior Female Volleyball Players*. Int J Environ Res Public Health. 18: 8377-8386 (2021).

Ramírez-Vélez, R. et al., *Vertical Jump and Leg Power Normative Data for Colombian Schoolchildren Aged 9-17.9 Years: The FUPRECOL Study*. J Strength Cond Res. 31: 990-998 (2017).

Roberts, S.A., J.M. Carswell. *Growth, growth potential, and influences on adult height in the transgender and gender-diverse population*. Andrology. 9:1679-1688 (2021).

Roberts, T.A. et al., *Effect of gender affirming hormones on athletic performance in transwomen and transmen: implications for sporting organisations and legislators*. Br J Sports Med published online at 10.1136/bjsports-2020-102329 (Dec. 7, 2020).

Roser, M., Cameron Appel and Hannah Ritchie (2013) "Human Height". Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/human-height [Online Resource]

Ross, J.G. and G.G. Gilbert. *National Children and Youth Fitness Study*. J Physical Educ Rec Dance (JOPERD) 56: 45 – 50 (1985).

Sakamoto, K. et al., *Comparison of kicking speed between female and male soccer players*. Procedia Eng 72:50-55 (2014).

Santos, R. et al. *Physical fitness percentiles for Portuguese children and adolescents aged 10-18 years*. J Sports Sci. 32:1510-8. (2014).

Sattler, T. et al., *Vertical jump performance of professional male and female volleyball players: effects of playing position and competition level*. J Strength & Cond Res 29(6):1486-93 (2015).

Sax L. *How common is intersex? a response to Anne Fausto-Sterling*. J Sex Res. 39(3):174-8 (2002).

Scharff, M. et al., *Change in grip strength in trans people and its association with lean body mass and bone density*. Endocrine Connections 8:1020-28 (2019).

Senefeld, J.W., et al. *Divergence in timing and magnitude of testosterone levels between male and female youths*, JAMA 324(1):99-101 (2020).

Shah, K. et al. *Do you know the sex of your cells?* Am J Physiol Cell Physiol. 306(1):C3-18 (2014).

Silverman, I., *The secular trend for grip strength in Canada and the United States*, J Sports Sci 29(6):599-606 (2011).

Spierer, D. et al., *Gender influence on response time to sensory stimuli*. J Strength & Cond Res 24:4(957-63) (2010).

Staiano AE, Katzmarzyk PT. *Ethnic and sex differences in body fat and visceral and subcutaneous adiposity in children and adolescents*. Int J Obes (Lond). 36:1261-9. (2012).

Tack, L.J.W. et al., *Proandrogenic and antiandrogenic progestins in transgender youth: differential effects on body composition and bone metabolism*. J. Clin. Endocrinol. Metab, 103(6):2147-56 (2018).

Tambalis, K. et al., *Physical fitness normative values for 6-18-year-old Greek boys and girls, using the empirical distribution and the lambda, mu, and sigma statistical method*. Eur J Sports Sci 16:6(736-46) (2016).

Taylor, M.J. et al., *Vertical jumping and leg power normative data for English school children aged 10-15 years*. J Sports Sci. 28:867-72. (2010).

Taylor RW, Gold E, Manning P, and Goulding A. *Gender differences in body fat content are present well before puberty*. Int J Obes Relat Metab Disord 21: 1082-1084, 1997.

Taylor RW, Grant AM, Williams SM, and Goulding A. *Sex differences in regional body fat distribution from pre- to postpuberty*. Obesity (Silver Spring) 18: 1410-1416, 2010.

Thibault, V., M. Guillaume et al., *Women and men in sport performance: the gender gap has not evolved since 1983*. J Sports Science & Med 9:214-223 (2010).

Thomas, J.R. and K. E. French, *Gender differences across age in motor performance: a meta-analysis*. Psych. Bull. 98(2):260-282 (1985).

Tomkinson, G. et al., *European normative values for physical fitness in children and adolescents aged 9-17 years: results from 2,779,165 Eurofit performances representing 30 countries*. Br J Sports Med 52:1445-56 (2018).

Tomkinson, G. et al., *International normative 20 m shuttle run values from 1,142,026 children and youth representing 50 countries*. Br J Sports Med. 51:1545-1554 (2017).

Tønnessen, E., I. S. Svendsen et al., *Performance development in adolescent track & field athletes according to age, sex, and sport discipline.* PLoS ONE 10(6): e0129014 (2015).

Tønnessen, E. et al., *Reaction time aspects of elite sprinters in athletic world championships*. J Strength & Cond Res 27(4):885-92 (2013).

United Kingdom Sports Councils, *Guidance for transgender inclusion in domestic sport*. Available at https://equalityinsport.org/docs/300921/Guidance for Transgender Inclusion in Domestic Sport 2021 - Summary of Background Documents.pdf. September 2021.

United Kingdom Sports Councils, *International Research Literature Review*. Available at https://equalityinsport.org/docs/300921/Transgender%20International%20Research%20Literature%20Review%202021.pdf. September 2021.

USA Swimming Athlete Inclusion Procedures, last revision February 1, 2022, available at https://www.usaswimming.org/docs/default-source/governance/governance-lsc-website/rules_policies/usa-swimming-policy-19.pdf.

VanCaenegem, E. et al, *Preservation of volumetric bone density and geometry in trans women during cross-sex hormonal therapy: a prospective observational study*. Osteoporos Int 26:35-47 (2015).

Wiik, A., T. R Lundberg et al., *Muscle strength, size, and composition following 12 months of gender-affirming treatment in transgender individuals*. J. Clinical Endocrin. & Metab. 105(3):e805-813 (2020).

Women's Sports Policy Working Group, *Briefing book: a request to Congress and the administration to preserve girls' and women's sport and accommodate transgender athletes.* Available at womenssportspolicy.org. (2021).

World Rugby Transgender Guidelines. https://www.world.rugby/the-game/player-welfare/guidelines/transgender (2020).

World Rugby Transgender Women's Guidelines. https://www.world.rugby/the-game/player-welfare/guidelines/transgender/women (2020).

Wunderlich RE, Cavanagh PR. *Gender differences in adult foot shape: implications for shoe design*. Med Sci Sports Exerc. 33:605-1 (2001).

Appendix 1 – Data Tables

Presidential Physical Fitness Results[14]

Curl-Ups (# in 1 minute)

	Male		Female			Male-Female % Difference	
Age	50th %ile	85th %ile	50th %ile	85th %ile	Age	50th %ile	85th %ile
6	22	33	23	32	6	-4.3%	3.1%
7	28	36	25	34	7	12.0%	5.9%
8	31	40	29	38	8	6.9%	5.3%
9	32	41	30	39	9	6.7%	5.1%
10	35	45	30	40	10	16.7%	12.5%
11	37	47	32	42	11	15.6%	11.9%
12	40	50	35	45	12	14.3%	11.1%
13	42	53	37	46	13	13.5%	15.2%
14	45	56	37	47	14	21.6%	19.1%
15	45	57	36	48	15	25.0%	18.8%
16	45	56	35	45	16	28.6%	24.4%
17	44	55	34	44	17	29.4%	25.0%

[14] This data is available from a variety of sources. including: https://gilmore.gvsd.us/documents/Info/Forms/Teacher%20Forms/Presidentialchallengetest.pdf

Shuttle Run (seconds)

	Male		Female			Male-Female % Difference	
Age	50th %ile	85th %ile	50th %ile	85th %ile	Age	50th %ile	85th %ile
6	13.3	12.1	13.8	12.4	6	3.6%	2.4%
7	12.8	11.5	13.2	12.1	7	3.0%	5.0%
8	12.2	11.1	12.9	11.8	8	5.4%	5.9%
9	11.9	10.9	12.5	11.1	9	4.8%	1.8%
10	11.5	10.3	12.1	10.8	10	5.0%	4.6%
11	11.1	10	11.5	10.5	11	3.5%	4.8%
12	10.6	9.8	11.3	10.4	12	6.2%	5.8%
13	10.2	9.5	11.1	10.2	13	8.1%	6.9%
14	9.9	9.1	11.2	10.1	14	11.6%	9.9%
15	9.7	9.0	11.0	10.0	15	11.8%	10.0%
16	9.4	8.7	10.9	10.1	16	13.8%	13.9%
17	9.4	8.7	11.0	10.0	17	14.5%	13.0%

1 mile run (seconds)

	Male		Female			Male-Female % Difference	
Age	50th %ile	85th %ile	50th %ile	85th %ile	Age	50th %ile	85th %ile
6	756	615	792	680	6	4.5%	9.6%
7	700	562	776	636	7	9.8%	11.6%
8	665	528	750	602	8	11.3%	12.3%
9	630	511	712	570	9	11.5%	10.4%
10	588	477	682	559	10	13.8%	14.7%
11	560	452	677	542	11	17.3%	16.6%
12	520	431	665	503	12	21.8%	14.3%
13	486	410	623	493	13	22.0%	16.8%
14	464	386	606	479	14	23.4%	19.4%
15	450	380	598	488	15	24.7%	22.1%
16	430	368	631	503	16	31.9%	26.8%
17	424	366	622	495	17	31.8%	26.1%

Pull Ups (# completed)

	Male		Female			Male-Female % Difference	
Age	50th %ile	85th %ile	50th %ile	85th %ile	Age	50th %ile	85th %ile
6	1	2	1	2	6	0.0%	0.0%
7	1	4	1	2	7	0.0%	100.0%
8	1	5	1	2	8	0.0%	150.0%
9	2	5	1	2	9	100.0%	150.0%
10	2	6	1	3	10	100.0%	100.0%
11	2	6	1	3	11	100.0%	100.0%
12	2	7	1	2	12	100.0%	250.0%
13	3	7	1	2	13	200.0%	250.0%
14	5	10	1	2	14	400.0%	400.0%
15	6	11	1	2	15	500.0%	450.0%
16	7	11	1	1	16	600.0%	1000.0%
17	8	13	1	1	17	700.0%	1200.0%

Data Compiled from Athletic.Net

2021 National 3000 m cross country race time in seconds

	7-8 years old			9-10 years old			11-12 year old		
Rank	Boys	Girls		Boys	Girls		Boys	Girls	
1	691.8	728.4	Difference	607.7	659.8	Difference	608.1	632.6	Difference
2	722.5	739.0	#1 boy vs #	619.6	674.0	#1 boy vs #	608.7	639.8	#1 boy vs #
3	740.5	783.0	1 girl	620.1	674.7	1 girl	611.3	664.1	1 girl
4	759.3	783.5	5.0%	643.2	683.7	7.9%	618.6	664.4	3.9%
5	759.6	792.8		646.8	685.0		619.7	671.6	
6	760.0	824.1		648.0	686.4		631.2	672.1	
7	772.0	825.7	Average	648.8	687.0	Average	631.7	672.3	Average
8	773.0	832.3	difference	658.0	691.0	difference	634.9	678.4	difference
9	780.7	834.3	boys vs girls	659.5	692.2	boys vs girls	635.0	679.3	boys vs girls
10	735.1	844.4	6.2%	663.9	663.3	5.6%	635.1	679.4	6.3%

2021 National 3000 m cross country race time in seconds

	5th grade			6th grade			7th grade		
Rank	Boys	Girls		Boys	Girls		Boys	Girls	
1	625.5	667.0	Difference	545.3	582.0	Difference	534.0	560.7	Difference
2	648.8	685.0	#1 boy vs #	553.2	584.3	#1 boy vs #	541.0	567.0	#1 boy vs #
3	653.5	712.9	1 girl	562.3	585.1	1 girl	542.6	581.8	1 girl
4	658.4	719.2	6.2%	562.9	599.8	6.3%	544.6	583.0	4.8%
5	675.3	725.2		571.5	612.9		546.0	595.0	
6	677.4	727.7		588.0	622.0		556.0	599.0	
7	677.6	734.0	Average	591.3	624.9	Average	556.0	604.3	Average
8	679.1	739.4	difference	593.0	626.0	difference	556.0	606.0	difference
9	686.4	739.4	boys vs girls	593.8	628.0	boys vs girls	558.6	606.8	boys vs girls
10	686.4	746.4	7.3%	594.1	645.6	5.8%	563.2	617.0	7.1%

2021 National 100 m Track race time in seconds

	7-8 years old			9-10 years old			11-12 year old		
Rank	Boys	Girls		Boys	Girls		Boys	Girls	
1	13.06	14.24	Difference #1	10.87	12.10	Difference #1	11.37	12.08	Difference #1
2	13.54	14.41	boy vs # 1	10.91	12.24	boy vs # 1	11.61	12.43	boy vs # 1
3	13.73	14.44	girl	11.09	12.63	girl	11.73	12.51	girl
4	14.10	14.48	8.3%	11.25	12.70	10.2%	11.84	12.55	5.9%
5	14.19	14.49		11.27	12.75		11.89	12.57	
6	14.31	14.58		11.33	12.80		11.91	12.62	
7	14.34	14.69	Average	11.42	12.83	Average	11.94	12.65	Average
8	14.35	14.72	difference	11.43	12.84	difference	11.97	12.71	difference
9	14.41	14.77	boys vs girls	11.44	12.88	boys vs girls	12.08	12.71	boys vs girls
10	14.43	14.86	3.6%	11.51	12.91	11.1%	12.12	12.75	5.7%

2021 National 200 m Track race time in seconds

	7-8 years old			9-10 years old			11-12 year old		
Rank	Boys	Girls		Boys	Girls		Boys	Girls	
1	24.02	28.72	Difference #1	21.77	25.36	Difference #1	20.66	25.03	Difference #1
2	24.03	28.87	boy vs # 1	22.25	25.50	boy vs # 1	22.91	25.18	boy vs # 1
3	28.07	29.92	girl	22.48	25.55	girl	23.14	25.22	girl
4	28.44	29.95	16.4%	22.57	25.70	14.2%	23.69	25.49	17.5%
5	28.97	30.04		22.65	26.08		23.84	25.78	
6	29.26	30.09		22.77	26.22		24.23	25.89	
7	29.34	30.27	Average	23.11	26.79	Average	24.35	26.03	Average
8	29.38	30.34	difference	23.16	26.84	difference	24.58	26.07	difference
9	29.65	30.41	boys vs girls	23.28	26.91	boys vs girls	24.59	26.10	boys vs girls
10	29.78	30.54	6.1%	23.47	26.85	13.1%	24.61	26.13	7.9%

2021 National 400 m Track race time in seconds

	7-8 years old			9-10 years old			11-12 year old		
Rank	Boys	Girls		Boys	Girls		Boys	Girls	
1	66.30	67.12	Difference #1	49.29	56.80	Difference #1	51.96	55.70	Difference #1
2	66.88	67.67	boy vs # 1	50.47	58.57	boy vs # 1	55.52	57.08	boy vs # 1
3	67.59	67.74	girl	52.28	60.65	girl	55.58	57.60	girl
4	68.16	68.26	1.2%	52.44	61.45	13.2%	55.59	57.79	6.7%
5	68.51	68.37		53.31	61.81		55.72	58.02	
6	69.13	71.02		53.65	62.03		55.84	58.25	
7	69.75	72.73	Average	53.78	62.32	Average	55.92	59.25	Average
8	69.80	73.25	difference	54.51	62.33	difference	57.12	59.27	difference
9	69.81	73.31	boys vs girls	55.84	62.34	boys vs girls	57.18	59.40	boys vs girls
10	70.32	73.48	2.4%	55.90	62.40	13.0%	57.22	59.49	4.2%

2021 National 800 m Track race time in seconds

	7-8 years old			9-10 years old			11-12 year old		
Rank	Boys	Girls		Boys	Girls		Boys	Girls	
1	152.2	157.9	Difference #1	120.8	141.4	Difference #1	127.8	138.5	Difference #1
2	155.2	164.6	boy vs # 1	124.0	142.2	boy vs # 1	129.7	143.1	boy vs # 1
3	161.0	164.9	girl	125.1	148.8	girl	130.5	144.2	girl
4	161.1	165.9	3.6%	125.6	151.3	14.5%	133.2	144.2	7.7%
5	161.2	168.5		126.5	151.6		136.2	144.9	
6	161.6	169.9		136.5	152.5		136.5	145.0	
7	161.8	171.5	Average	137.1	153.1	Average	136.7	145.2	Average
8	162.2	173.1	difference	138.5	153.7	difference	136.7	145.6	difference
9	165.3	173.4	boys vs girls	139.5	153.8	boys vs girls	137.0	145.6	boys vs girls
10	166.9	174.7	4.5%	140.2	154.2	12.6%	137.9	145.8	6.9%

2021 National 1600 m Track race time in seconds

	7-8 years old			9-10 years old			11-12 year old		
Rank	Boys	Girls		Boys	Girls		Boys	Girls	
1	372.4	397.6	Difference #1	307.4	319.3	Difference #1	297.3	313.8	Difference #1
2	378.3	400.9	boy vs # 1	313.7	322.2	boy vs # 1	298.4	317.1	boy vs # 1
3	378.4	405.6	girl	315.0	322.6	girl	307.0	319.9	girl
4	402.0	435.2	6.3%	318.2	337.5	3.7%	313.9	323.3	5.2%
5	406.4	445.0		318.4	345.2		319.2	325.3	
6	413.4	457.0		320.5	345.7		320.4	326.2	
7	457.4	466.0	Average	327.0	345.9	Average	321.1	327.0	Average
8	473.3	466.8	difference	330.3	347.1	difference	321.9	330.0	difference
9	498.3	492.3	boys vs girls	333.4	347.5	boys vs girls	325.5	331.1	boys vs girls
10	505.0	495.0	4.0%	347.0	355.6	4.7%	327.1	332.5	2.9%

2021 National 3000 m Track race time in seconds

	7-8 years old			9-10 years old			11-12 year old		
Rank	Boys	Girls		Boys	Girls		Boys	Girls	
1	794.2	859.9	Difference #1	602.3	679.2	Difference #1	556.6	623.7	Difference #1
2	856.3		boy vs # 1	644.9	709.7	boy vs # 1	591.6	649.5	boy vs # 1
3			girl	646.6	714.2	girl	600.8	651.6	girl
4			7.6%	648.2	741.9	11.3%	607.1	654.9	10.8%
5	No further data	No Further Data		648.4	742.7		609.1	662.9	
6				652.8	756.6		611.5	664.1	
7			Average	658.9	760.2	Average	615.7	666.3	Average
8			difference	660.1	762.5	difference	617.3	666.8	difference
9			boys vs girls	662.7	780.2	boys vs girls	618.4	673.2	boys vs girls
10			NA%	671.6	792.3	12.7%	620.6	674.4	8.2%

2021 National Long Jump Distance (in inches)

	7-8 years old			9-10 years old			11-12 year old		
Rank	Boys	Girls		Boys	Girls		Boys	Girls	
1	156.0	176.0	Difference #1	256.8	213.8	Difference #1	224.0	201.3	Difference #1
2	156.0	163.8	boy vs # 1	247.0	212.0	boy vs # 1	222.5	197.3	boy vs # 1
3	155.0	153.0	girl	241.0	210.8	girl	220.5	195.8	girl
4	154.3	152.0	-11.4%	236.3	208.8	20.1%	210.3	193.5	11.3%
5	154.0	149.5		231.5	207.0		210.0	193.3	
6	152.8	146.0		225.0	204.8		206.8	192.5	
7	151.5	144.5	Average	224.0	194.5	Average	206.0	192.3	Average
8	150.8	137.5	difference	224.0	192.5	difference	205.5	192.0	difference
9	150.5	137.0	boys vs girls	221.8	192.3	boys vs girls	205.0	191.3	boys vs girls
10		No Further Data	1.4%			13.2%			9.1%
	150.5			219.0	187.5		204.5	189.0	

2021 National High Jump Distance (in inches)

	7-8 years old			9-10 years old			11-12 year old		
Rank	Boys	Girls		Boys	Girls		Boys	Girls	
1	38.0	37.5	Difference #1	72.0	58.0	Difference #1	63.0	56.0	Difference #1
2	38.0	34.0	boy vs # 1	70.0	58.0	boy vs # 1	61.0	56.0	boy vs # 1
3	36.0	32.0	girl	65.8	57.0	girl	60.0	57.0	girl
4	36.0	32.0	1.3	62.0	56.0	24.1%	59.0	56.0	12.5%
5	35.8	32.0		62.0	56.0		59.0	56.0	
6	35.5			62.0	55.0		59.0	55.0	
7	34.0		Average	61.0	54.0	Average	59.0	54.0	Average
8	32.0	No further Data	difference	60.0	54.0	difference	58.0	54.0	difference
9	59.0		boys vs girls	59.0	No	boys vs girls	57.8	56.0	boys vs girls
10			21.6%		Further	12.5%			6.9%
	56.0			56.0	Data		57.8	56.0	

Appendix 2 – Scholarly Publications in Past 10 Years

Refereed Publications

1. Brown GA, Shaw BS, Shaw I. How much water is in a mouthful, and how many mouthfuls should I drink? A laboratory exercise to help students understand developing a hydration plan. Adv Physiol Educ 45: 589–593, 2021.
2. Schneider KM and Brown GA (as Faculty Mentor). What's at Stake: Is it a Vampire or a Virus? International Journal of Undergraduate Research and Creative Activities. 11, Article 4. 2019.
3. Christner C and Brown GA (as Faculty Mentor). Explaining the Vampire Legend through Disease. UNK Undergraduate Research Journal. 23(1), 2019. (*This is an on-campus publication.)
4. Schneekloth B and Brown GA. Comparison of Physical Activity during Zumba with a Human or Video Game Instructor. 11(4):1019-1030. International Journal of Exercise Science, 2018.
5. Bice MR, Hollman A, Bickford S, Bickford N, Ball JW, Wiedenman EM, Brown GA, Dinkel D, and Adkins M. Kinesiology in 360 Degrees. International Journal of Kinesiology in Higher Education, 1: 9-17, 2017
6. Shaw I, Shaw BS, Brown GA, and Shariat A. Review of the Role of Resistance Training and Musculoskeletal Injury Prevention and Rehabilitation. Gavin Journal of Orthopedic Research and Therapy. 1: 5-9, 2016
7. Kahle A, Brown GA, Shaw I, & Shaw BS. Mechanical and Physiological Analysis of Minimalist versus Traditionally Shod Running. J Sports Med Phys Fitness. 56(9):974-9, 2016
8. Bice MR, Carey J, Brown GA, Adkins M, and Ball JW. The Use of Mobile Applications to Enhance Learning of the Skeletal System in Introductory Anatomy & Physiology Students. Int J Kines Higher Educ 27(1) 16-22, 2016
9. Shaw BS, Shaw I, & Brown GA. Resistance Exercise is Medicine. Int J Ther Rehab. 22: 233-237, 2015.
10. Brown GA, Bice MR, Shaw BS, & Shaw I. Online Quizzes Promote Inconsistent Improvements on In-Class Test Performance in Introductory Anatomy & Physiology. Adv. Physiol. Educ. 39: 63-6, 2015
11. Brown GA, Heiserman K, Shaw BS, & Shaw I. Rectus abdominis and rectus femoris muscle activity while performing conventional unweighted and weighted seated abdominal trunk curls. Medicina dello Sport. 68: 9-18. 2015
12. Botha DM, Shaw BS, Shaw I & Brown GA. Role of hyperbaric oxygen therapy in the promotion of cardiopulmonary health and rehabilitation. African Journal for

Physical, Health Education, Recreation and Dance (AJPHERD). Supplement 2 (September), 20: 62-73, 2014

13. Abbey BA, Heelan KA, Brown, GA, & Bartee RT. Validity of HydraTrend™ Reagent Strips for the Assessment of Hydration Status. J Strength Cond Res. 28: 2634-9. 2014

14. Scheer KC, Siebrandt SM, Brown GA, Shaw BS, & Shaw I. Wii, Kinect, & Move. Heart Rate, Oxygen Consumption, Energy Expenditure, and Ventilation due to Different Physically Active Video Game Systems in College Students. International Journal of Exercise Science: 7: 22-32, 2014

15. Shaw BS, Shaw I, & Brown GA. Effect of concurrent aerobic and resistive breathing training on respiratory muscle length and spirometry in asthmatics. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). Supplement 1 (November), 170-183, 2013

16. Adkins M, Brown GA, Heelan K, Ansorge C, Shaw BS & Shaw I. Can dance exergaming contribute to improving physical activity levels in elementary school children? African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). 19: 576-585, 2013

17. Jarvi MB, Brown GA, Shaw BS & Shaw I. Measurements of Heart Rate and Accelerometry to Determine the Physical Activity Level in Boys Playing Paintball. International Journal of Exercise Science: 6: 199-207, 2013

18. Brown GA, Krueger RD, Cook CM, Heelan KA, Shaw BS & Shaw I. A prediction equation for the estimation of cardiorespiratory fitness using an elliptical motion trainer. West Indian Medical Journal. 61: 114-117, 2013.

19. Shaw BS, Shaw I, & Brown GA. Body composition variation following diaphragmatic breathing. African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). 18: 787-794, 2012.

Refereed Presentations

1. Brown GA. Transwomen competing in women's sports: What we know, and what we don't. American Physiological Society New Trends in Sex and Gender Medicine conference. Held virtually due to Covid-19 pandemic. October 19 - 22, 2021, 2021.

2. Shaw BS, Boshoff VE, Coetzee S, Brown GA, Shaw I. A Home-based Resistance Training Intervention Strategy To Decrease Cardiovascular Disease Risk In Overweight Children Med Sci Sport Exerc. 53(5), 742. 68th Annual Meeting of the American College of Sports Medicine. Held virtually due to Covid-19 pandemic. June 1-5, 2021.

3. Shaw I, Cronje M, Brown GA, Shaw BS. Exercise Effects On Cognitive Function And Quality Of Life In Alzheimer's Patients In Long-term Care. Med

Sci Sport Exerc. 53(5), 743. 68th Annual Meeting of the American College of Sports Medicine. Held virtually due to Covid-19 pandemic. June 1-5, 2021.

4. Brown GA, Escalera M, Oleena A, Turek T, Shaw I, Shaw BS. Relationships between Body Composition, Abdominal Muscle Strength, and Well Defined Abdominal Muscles. Med Sci Sport Exerc. 53(5), 197. 68th Annual Meeting of the American College of Sports Medicine. Held virtually due to Covid-19 pandemic. June 1-5, 2021.
5. Brown GA, Jackson B, Szekely B, Schramm T, Shaw BS, Shaw I. A Pre-Workout Supplement Does Not Improve 400 M Sprint Running or Bicycle Wingate Test Performance in Recreationally Trained Individuals. Med Sci Sport Exerc. 50(5), 2932. 65th Annual Meeting of the American College of Sports Medicine. Minneapolis, MN. June 2018.
6. Paulsen SM, Brown GA. Neither Coffee Nor A Stimulant Containing "Pre-workout" Drink Alter Cardiovascular Drift During Walking In Young Men. Med Sci Sport Exerc. 50(5), 2409. 65th Annual Meeting of the American College of Sports Medicine. Minneapolis, MN. June 2018.
7. Adkins M, Bice M, Bickford N, Brown GA. Farm to Fresh! A Multidisciplinary Approach to Teaching Health and Physical Activity. 2018 spring SHAPE America central district conference. Sioux Falls, SD. January 2018.
8. Shaw I, Kinsey JE, Richards R, Shaw BS, and Brown GA. Effect Of Resistance Training During Nebulization In Adults With Cystic Fibrosis. International Journal of Arts & Sciences' (IJAS). International Conference for Physical, Life and Health Sciences which will be held at FHWien University of Applied Sciences of WKW, at Währinger Gürtel 97, Vienna, Austria, from 25-29 June 2017.
9. Bongers M, Abbey BM, Heelan K, Steele JE, Brown GA. Nutrition Education Improves Nutrition Knowledge, Not Dietary Habits In Female Collegiate Distance Runners. Med Sci Sport Exerc. 49(5), 389. 64th Annual Meeting of the American College of Sports Medicine. Denver, CO. May 2017.
10. Brown GA, Steele JE, Shaw I, Shaw BS. Using Elisa to Enhance the Biochemistry Laboratory Experience for Exercise Science Students. Med Sci Sport Exerc. 49(5), 1108. 64th Annual Meeting of the American College of Sports Medicine. Denver, CO. May 2017.
11. Brown GA, Shaw BS, and Shaw I. Effects of a 6 Week Conditioning Program on Jumping, Sprinting, and Agility Performance In Youth. Med Sci Sport Exerc. 48(5), 3730. 63rd Annual Meeting of the American College of Sports Medicine. Boston, MA. June 2016.
12. Shaw I, Shaw BS, Boshoff VE, Coetzee S, and Brown GA. Kinanthropometric Responses To Callisthenic Strength Training In Children. Med Sci Sport Exerc.

48(5), 3221. 63rd Annual Meeting of the American College of Sports Medicine. Boston, MA. June 2016.

13. Shaw BS, Shaw I, Gouveia M, McIntyre S, and Brown GA. Kinanthropometric Responses To Moderate-intensity Resistance Training In Postmenopausal Women. Med Sci Sport Exerc. 48(5), 2127. 63rd Annual Meeting of the American College of Sports Medicine. Boston, MA. June 2016.
14. Bice MR, Cary JD, Brown GA, Adkins M, and Ball JW. The use of mobile applications to enhance introductory anatomy & physiology student performance on topic specific in-class tests. National Association for Kinesiology in Higher Education National Conference. January 8, 2016.
15. Shaw I, Shaw BS, Lawrence KE, Brown GA, and Shariat A. Concurrent Resistance and Aerobic Exercise Training Improves Hemodynamics in Normotensive Overweight and Obese Individuals. Med Sci Sport Exerc. 47(5), 559. 62nd Annual Meeting of the American College of Sports Medicine. San Diego, CA. May 2015.
16. Shaw BS, Shaw I, McCrorie C, Turner S., Schnetler A, and Brown GA. Concurrent Resistance and Aerobic Training in the Prevention of Overweight and Obesity in Young Adults. Med Sci Sport Exerc. 47(5), 223. 62nd Annual Meeting of the American College of Sports Medicine. San Diego, CA. May 2015.
17. Schneekloth B, Shaw I, Shaw BS, and Brown GA. Physical Activity Levels Using Kinect™ Zumba Fitness versus Zumba Fitness with a Human Instructor. Med Sci Sport Exerc. 46(5), 326. 61st Annual Meeting of the American College of Sports Medicine. Orlando, FL. June 2014.
18. Shaw I, Lawrence KE, Shaw BS, and Brown GA. Callisthenic Exercise-related Changes in Body Composition in Overweight and Obese Adults. Med Sci Sport Exerc. 46(5), 394. 61st Annual Meeting of the American College of Sports Medicine. Orlando, FL June 2014.
19. Shaw BS, Shaw I, Fourie M, Gildenhuys M, and Brown GA. Variances In The Body Composition Of Elderly Woman Following Progressive Mat Pilates. Med Sci Sport Exerc. 46(5), 558. 61st Annual Meeting of the American College of Sports Medicine. Orlando, FL June 2014.
20. Brown GA, Shaw I, Shaw BS, and Bice M. Online Quizzes Enhance Introductory Anatomy & Physiology Performance on Subsequent Tests, But Not Examinations. Med Sci Sport Exerc. 46(5), 1655. 61st Annual Meeting of the American College of Sports Medicine. Orlando, FL June 2014.
21. Kahle, A. and Brown, G.A. Electromyography in the Gastrocnemius and Tibialis Anterior, and Oxygen Consumption, Ventilation, and Heart Rate During Minimalist versus Traditionally Shod Running. 27th National Conference on Undergraduate Research (NCUR). La Crosse, Wisconsin USA. April 11-13, 2013

22. Shaw, I., Shaw, B.S., and Brown, G.A. Resistive Breathing Effects on Pulmonary Function, Aerobic Capacity and Medication Usage in Adult Asthmatics Med Sci Sports Exerc 45 (5). S1602 2013. 60th Annual Meeting of the American College of Sports Medicine, Indianapolis, IN USA, May 26-30 3013
23. Shaw, B.S. Gildenhuys, G.A., Fourie, M. Shaw I, and Brown, G.A. Function Changes In The Aged Following Pilates Exercise Training. Med Sci Sports Exerc 45 (5). S1566 60th Annual Meeting of the American College of Sports Medicine, Indianapolis, IN USA, May 26-30 2013
24. Brown, G.A., Abbey, B.M., Ray, M.W., Shaw B.S., & Shaw, I. Changes in Plasma Free Testosterone and Cortisol Concentrations During Plyometric Depth Jumps. Med Sci Sports Exerc 44 (5). S598, 2012. 59th Annual Meeting of the American College of Sports Medicine. May 29 - June 2, 2012; San Francisco, California
25. Shaw, I., Fourie, M., Gildenhuys, G.M., Shaw B.S., & Brown, G.A. Group Pilates Program and Muscular Strength and Endurance Among Elderly Woman. Med Sci Sports Exerc 44 (5). S1426. 59th Annual Meeting of the American College of Sports Medicine. May 29 - June 2, 2012; San Francisco, California
26. Shaw B.S., Shaw, I., & Brown, G.A. Concurrent Inspiratory-Expiratory and Aerobic Training Effects On Respiratory Muscle Strength In Asthmatics. Med Sci Sports Exerc 44 (5). S2163. 59th Annual Meeting of the American College of Sports Medicine. May 29 - June 2, 2012; San Francisco, California
27. Scheer, K., Siebrandt, S., Brown, G.A, Shaw B.S., & Shaw, I. Heart Rate, Oxygen Consumption, and Ventilation due to Different Physically Active Video Game Systems. Med Sci Sports Exerc 44 (5). S1763. 59th Annual Meeting of the American College of Sports Medicine. May 29 - June 2, 2012; San Francisco, California
28. Jarvi M.B., Shaw B.S., Shaw, I., & Brown, G.A. (2012) Paintball Is A Blast, But Is It Exercise? Heart Rate and Accelerometry In Boys Playing Paintball. Med Sci Sports Exerc 44 (5). S3503. 59th Annual Meeting of the American College of Sports Medicine. May 29 - June 2, 2012; San Francisco, California

Book Chapters

1. Shaw BS, Shaw I, Brown G.A. Importance of resistance training in the management of cardiovascular disease risk. In Cardiovascular Risk Factors. IntechOpen, 2021.

2. Brown, G.A. Chapters on Androstenedione and DHEA. In: Nutritional Supplements in Sport, Exercise and Health an A-Z Guide. edited by Linda M. Castell, Samantha J. Stear, Louise M. Burke. Routledge 2015.

Refereed Web Content

1. Brown GA. Looking back and moving forward. The importance of reflective assessment in physiology education. (January 13, 2022) https://blog.lifescitrc.org/pecop/2022/01/13/looking-back-and-moving-forward-the-importance-of-reflective-assessment-in-physiology-education/
2. Brown GA. The Olympics, sex, and gender in the physiology classroom. Physiology Educators Community of Practice, managed by the Education group of the American Physiological Society (August 18, 2021) https://blog.lifescitrc.org/pecop/2021/08/18/the-olympics-sex-and-gender-in-the-physiology-classroom/

A complete CV is available at
https://www.unk.edu/academics/hperls/bio_pages/current-vita-gab.pdf

Exhibit C

Endocrine Treatment of Gender-Dysphoric/ Gender-Incongruent Persons: An Endocrine Society* Clinical Practice Guideline

Wylie C. Hembree,[1] Peggy T. Cohen-Kettenis,[2] Louis Gooren,[3] Sabine E. Hannema,[4] Walter J. Meyer,[5] M. Hassan Murad,[6] Stephen M. Rosenthal,[7] Joshua D. Safer,[8] Vin Tangpricha,[9] and Guy G. T'Sjoen[10]

[1]New York Presbyterian Hospital, Columbia University Medical Center, New York, New York 10032 (Retired); [2]VU University Medical Center, 1007 MB Amsterdam, Netherlands (Retired); [3]VU University Medical Center, 1007 MB Amsterdam, Netherlands (Retired); [4]Leiden University Medical Center, 2300 RC Leiden, Netherlands; [5]University of Texas Medical Branch, Galveston, Texas 77555; [6]Mayo Clinic Evidence-Based Practice Center, Rochester, Minnesota 55905; [7]University of California San Francisco, Benioff Children's Hospital, San Francisco, California 94143; [8]Boston University School of Medicine, Boston, Massachusetts 02118; [9]Emory University School of Medicine and the Atlanta VA Medical Center, Atlanta, Georgia 30322; and [10]Ghent University Hospital, 9000 Ghent, Belgium

*Cosponsoring Associations: American Association of Clinical Endocrinologists, American Society of Andrology, European Society for Pediatric Endocrinology, European Society of Endocrinology, Pediatric Endocrine Society, and World Professional Association for Transgender Health.

Objective: To update the "Endocrine Treatment of Transsexual Persons: An Endocrine Society Clinical Practice Guideline," published by the Endocrine Society in 2009.

Participants: The participants include an Endocrine Society–appointed task force of nine experts, a methodologist, and a medical writer.

Evidence: This evidence-based guideline was developed using the Grading of Recommendations, Assessment, Development, and Evaluation approach to describe the strength of recommendations and the quality of evidence. The task force commissioned two systematic reviews and used the best available evidence from other published systematic reviews and individual studies.

Consensus Process: Group meetings, conference calls, and e-mail communications enabled consensus. Endocrine Society committees, members and cosponsoring organizations reviewed and commented on preliminary drafts of the guidelines.

Conclusion: Gender affirmation is multidisciplinary treatment in which endocrinologists play an important role. Gender-dysphoric/gender-incongruent persons seek and/or are referred to endocrinologists to develop the physical characteristics of the affirmed gender. They require a safe and effective hormone regimen that will (1) suppress endogenous sex hormone secretion determined by the person's genetic/gonadal sex and (2) maintain sex hormone levels within the normal range for the person's affirmed gender. Hormone treatment is not recommended for prepubertal gender-dysphoric/gender-incongruent persons. Those clinicians who recommend gender-affirming endocrine treatments—appropriately trained diagnosing clinicians (required), a mental health provider for adolescents (required) and mental health

ISSN Print 0021-972X ISSN Online 1945-7197
Printed in USA

Received 24 July 2017. Accepted 24 August 2017.
First Published Online 13 September 2017

Abbreviations: BMD, bone mineral density; DSD, disorder/difference of sex development; DSM, Diagnostic and Statistical Manual of Mental Disorders; GD, gender dysphoria; GnRH, gonadotropin-releasing hormone; ICD, International Statistical Classification of Diseases and Related Health Problems; MHP, mental health professional; VTE, venous thromboembolism.

professional for adults (recommended)—should be knowledgeable about the diagnostic criteria and criteria for gender-affirming treatment, have sufficient training and experience in assessing psychopathology, and be willing to participate in the ongoing care throughout the endocrine transition. We recommend treating gender-dysphoric/gender-incongruent adolescents who have entered puberty at Tanner Stage G2/B2 by suppression with gonadotropin-releasing hormone agonists. Clinicians may add gender-affirming hormones after a multidisciplinary team has confirmed the persistence of gender dysphoria/gender incongruence and sufficient mental capacity to give informed consent to this partially irreversible treatment. Most adolescents have this capacity by age 16 years old. We recognize that there may be compelling reasons to initiate sex hormone treatment prior to age 16 years, although there is minimal published experience treating prior to 13.5 to 14 years of age. For the care of peripubertal youths and older adolescents, we recommend that an expert multidisciplinary team comprised of medical professionals and mental health professionals manage this treatment. The treating physician must confirm the criteria for treatment used by the referring mental health practitioner and collaborate with them in decisions about gender-affirming surgery in older adolescents. For adult gender-dysphoric/gender-incongruent persons, the treating clinicians (collectively) should have expertise in transgender-specific diagnostic criteria, mental health, primary care, hormone treatment, and surgery, as needed by the patient. We suggest maintaining physiologic levels of gender-appropriate hormones and monitoring for known risks and complications. When high doses of sex steroids are required to suppress endogenous sex steroids and/or in advanced age, clinicians may consider surgically removing natal gonads along with reducing sex steroid treatment. Clinicians should monitor both transgender males (female to male) and transgender females (male to female) for reproductive organ cancer risk when surgical removal is incomplete. Additionally, clinicians should persistently monitor adverse effects of sex steroids. For gender-affirming surgeries in adults, the treating physician must collaborate with and confirm the criteria for treatment used by the referring physician. Clinicians should avoid harming individuals (via hormone treatment) who have conditions other than gender dysphoria/gender incongruence and who may not benefit from the physical changes associated with this treatment. **(*J Clin Endocrinol Metab* 102: 3869–3903, 2017)**

Summary of Recommendations

1.0 Evaluation of youth and adults

1.1. We advise that only trained mental health professionals (MHPs) who meet the following criteria should diagnose gender dysphoria (GD)/gender incongruence in adults: (1) competence in using the Diagnostic and Statistical Manual of Mental Disorders (DSM) and/or the International Statistical Classification of Diseases and Related Health Problems (ICD) for diagnostic purposes, (2) the ability to diagnose GD/gender incongruence and make a distinction between GD/gender incongruence and conditions that have similar features (*e.g.*, body dysmorphic disorder), (3) training in diagnosing psychiatric conditions, (4) the ability to undertake or refer for appropriate treatment, (5) the ability to psychosocially assess the person's understanding, mental health, and social conditions that can impact gender-affirming hormone therapy, and (6) a practice of regularly attending relevant professional meetings. (Ungraded Good Practice Statement)

1.2. We advise that only MHPs who meet the following criteria should diagnose GD/gender incongruence in children and adolescents: (1) training in child and adolescent developmental psychology and psychopathology, (2) competence in using the DSM and/or the ICD for diagnostic purposes, (3) the ability to make a distinction between GD/gender incongruence and conditions that have similar features (*e.g.*, body dysmorphic disorder), (4) training in diagnosing psychiatric conditions, (5) the ability to undertake or refer for appropriate treatment, (6) the ability to psychosocially assess the person's understanding and social conditions that can impact gender-affirming hormone therapy, (7) a practice of regularly attending relevant professional meetings, and (8) knowledge of the criteria for puberty blocking and gender-affirming hormone treatment in adolescents. (Ungraded Good Practice Statement)

1.3. We advise that decisions regarding the social transition of prepubertal youths with GD/gender incongruence are made with the assistance of an MHP or another experienced professional. (Ungraded Good Practice Statement).

doi: 10.1210/jc.2017-01658

1.4. We recommend against puberty blocking and gender-affirming hormone treatment in prepubertal children with GD/gender incongruence. (1 |⊕⊕◯◯)

1.5. We recommend that clinicians inform and counsel all individuals seeking gender-affirming medical treatment regarding options for fertility preservation prior to initiating puberty suppression in adolescents and prior to treating with hormonal therapy of the affirmed gender in both adolescents and adults. (1 |⊕⊕⊕◯)

2.0 Treatment of adolescents

2.1. We suggest that adolescents who meet diagnostic criteria for GD/gender incongruence, fulfill criteria for treatment, and are requesting treatment should initially undergo treatment to suppress pubertal development. (2 |⊕⊕◯◯)

2.2. We suggest that clinicians begin pubertal hormone suppression after girls and boys first exhibit physical changes of puberty. (2 |⊕⊕◯◯)

2.3. We recommend that, where indicated, GnRH analogues are used to suppress pubertal hormones. (1 |⊕⊕◯◯)

2.4. In adolescents who request sex hormone treatment (given this is a partly irreversible treatment), we recommend initiating treatment using a gradually increasing dose schedule after a multidisciplinary team of medical and MHPs has confirmed the persistence of GD/gender incongruence and sufficient mental capacity to give informed consent, which most adolescents have by age 16 years. (1 |⊕⊕◯◯).

2.5. We recognize that there may be compelling reasons to initiate sex hormone treatment prior to the age of 16 years in some adolescents with GD/gender incongruence, even though there are minimal published studies of gender-affirming hormone treatments administered before age 13.5 to 14 years. As with the care of adolescents ≥16 years of age, we recommend that an expert multidisciplinary team of medical and MHPs manage this treatment. (1 |⊕◯◯◯)

2.6. We suggest monitoring clinical pubertal development every 3 to 6 months and laboratory parameters every 6 to 12 months during sex hormone treatment. (2 |⊕⊕◯◯)

3.0 Hormonal therapy for transgender adults

3.1. We recommend that clinicians confirm the diagnostic criteria of GD/gender incongruence and the criteria for the endocrine phase of gender transition before beginning treatment. (1 |⊕⊕⊕◯)

3.2. We recommend that clinicians evaluate and address medical conditions that can be exacerbated by hormone depletion and treatment with sex hormones of the affirmed gender before beginning treatment. (1 |⊕⊕⊕◯)

3.3. We suggest that clinicians measure hormone levels during treatment to ensure that endogenous sex steroids are suppressed and administered sex steroids are maintained in the normal physiologic range for the affirmed gender. (2 |⊕⊕◯◯)

3.4. We suggest that endocrinologists provide education to transgender individuals undergoing treatment about the onset and time course of physical changes induced by sex hormone treatment. (2 |⊕◯◯◯)

4.0 Adverse outcome prevention and long-term care

4.1. We suggest regular clinical evaluation for physical changes and potential adverse changes in response to sex steroid hormones and laboratory monitoring of sex steroid hormone levels every 3 months during the first year of hormone therapy for transgender males and females and then once or twice yearly. (2 |⊕⊕◯◯)

4.2. We suggest periodically monitoring prolactin levels in transgender females treated with estrogens. (2 |⊕⊕◯◯)

4.3. We suggest that clinicians evaluate transgender persons treated with hormones for cardiovascular risk factors using fasting lipid profiles, diabetes screening, and/or other diagnostic tools. (2 |⊕⊕◯◯)

4.4. We recommend that clinicians obtain bone mineral density (BMD) measurements when risk factors for osteoporosis exist, specifically in those who stop sex hormone therapy after gonadectomy. (1 |⊕⊕◯◯)

4.5. We suggest that transgender females with no known increased risk of breast cancer follow breast-screening guidelines recommended for non-transgender females. (2 |⊕⊕◯◯)

4.6. We suggest that transgender females treated with estrogens follow individualized screening according to personal risk for prostatic disease and prostate cancer. (2 |⊕◯◯◯)

4.7. We advise that clinicians determine the medical necessity of including a total hysterectomy and oophorectomy as part of gender-affirming surgery. (Ungraded Good Practice Statement)

5.0 Surgery for sex reassignment and gender confirmation

5.1. We recommend that a patient pursue genital gender-affirming surgery only after the MHP and the clinician responsible for endocrine transition therapy both agree that surgery is medically necessary and would benefit the patient's overall health and/or well-being. (1 ⊕⊕◯◯)

5.2. We advise that clinicians approve genital gender-affirming surgery only after completion of at least 1 year of consistent and compliant hormone treatment, unless hormone therapy is not desired or medically contraindicated. (Ungraded Good Practice Statement)

5.3. We advise that the clinician responsible for endocrine treatment and the primary care provider ensure appropriate medical clearance of transgender individuals for genital gender-affirming surgery and collaborate with the surgeon regarding hormone use during and after surgery. (Ungraded Good Practice Statement)

5.4. We recommend that clinicians refer hormone-treated transgender individuals for genital surgery when: (1) the individual has had a satisfactory social role change, (2) the individual is satisfied about the hormonal effects, and (3) the individual desires definitive surgical changes. (1 ⊕◯◯◯)

5.5. We suggest that clinicians delay gender-affirming genital surgery involving gonadectomy and/or hysterectomy until the patient is at least 18 years old or legal age of majority in his or her country. (2 ⊕⊕◯◯).

5.6. We suggest that clinicians determine the timing of breast surgery for transgender males based upon the physical and mental health status of the individual. There is insufficient evidence to recommend a specific age requirement. (2 ⊕◯◯◯)

Changes Since the Previous Guideline

Both the current guideline and the one published in 2009 contain similar sections. Listed here are the sections contained in the current guideline and the corresponding number of recommendations: Introduction, Evaluation of Youth and Adults (5), Treatment of Adolescents (6), Hormonal Therapy for Transgender Adults (4), Adverse Outcomes Prevention and Long-term Care (7), and Surgery for Sex Reassignment and Gender Confirmation (6). The current introduction updates the diagnostic classification of "gender dysphoria/gender incongruence." It also reviews the development of "gender identity" and summarizes its natural development. The section on clinical evaluation of both youth and adults, defines in detail the professional qualifications required of those who diagnose and treat both adolescents and adults. We advise that decisions regarding the social transition of prepubertal youth are made with the assistance of a mental health professional or similarly experienced professional. We recommend against puberty blocking followed by gender-affirming hormone treatment of prepubertal children. Clinicians should inform pubertal children, adolescents, and adults seeking gender-confirming treatment of their options for fertility preservation. Prior to treatment, clinicians should evaluate the presence of medical conditions that may be worsened by hormone depletion and/or treatment. A multidisciplinary team, preferably composed of medical and mental health professionals, should monitor treatments. Clinicians evaluating transgender adults for endocrine treatment should confirm the diagnosis of persistent gender dysphoria/gender incongruence. Physicians should educate transgender persons regarding the time course of steroid-induced physical changes. Treatment should include periodic monitoring of hormone levels and metabolic parameters, as well as assessments of bone density and the impact upon prostate, gonads, and uterus. We also make recommendations for transgender persons who plan genital gender-affirming surgery.

Method of Development of Evidence-Based Clinical Practice Guidelines

The Clinical Guidelines Subcommittee (CGS) of the Endocrine Society deemed the diagnosis and treatment of individuals with GD/gender incongruence a priority area for revision and appointed a task force to formulate evidence-based recommendations. The task force followed the approach recommended by the Grading of Recommendations, Assessment, Development, and Evaluation group, an international group with expertise in the development and implementation of evidence-based guidelines (1). A detailed description of the grading scheme has been published elsewhere (2). The task force used the best available research evidence to develop the recommendations. The task force also used consistent language and graphical descriptions of both the strength of a recommendation and the quality of evidence. In terms of the strength of the recommendation, strong recommendations use the phrase "we recommend" and the number 1, and weak recommendations use the phrase "we suggest" and the number 2. Cross-filled circles indicate the quality of the evidence, such that ⊕◯◯◯ denotes very low–quality evidence; ⊕⊕◯◯, low quality; ⊕⊕⊕◯, moderate quality; and ⊕⊕⊕⊕, high quality. The task force has confidence that persons who receive care according to the strong recommendations will derive, on average, more benefit than harm. Weak recommendations require more careful consideration of the person's circumstances, values, and preferences to determine the best course of action. Linked to each recommendation is a description of the evidence and the

doi: 10.1210/jc.2017-01658

values that the task force considered in making the recommendation. In some instances, there are remarks in which the task force offers technical suggestions for testing conditions, dosing, and monitoring. These technical comments reflect the best available evidence applied to a typical person being treated. Often this evidence comes from the unsystematic observations of the task force and their preferences; therefore, one should consider these remarks as suggestions.

In this guideline, the task force made several statements to emphasize the importance of shared decision-making, general preventive care measures, and basic principles of the treatment of transgender persons. They labeled these "Ungraded Good Practice Statement." Direct evidence for these statements was either unavailable or not systematically appraised and considered out of the scope of this guideline. The intention of these statements is to draw attention to these principles.

The Endocrine Society maintains a rigorous conflict-of-interest review process for developing clinical practice guidelines. All task force members must declare any potential conflicts of interest by completing a conflict-of-interest form. The CGS reviews all conflicts of interest before the Society's Council approves the members to participate on the task force and periodically during the development of the guideline. All others participating in the guideline's development must also disclose any conflicts of interest in the matter under study, and most of these participants must be without any conflicts of interest. The CGS and the task force have reviewed all disclosures for this guideline and resolved or managed all identified conflicts of interest.

Conflicts of interest are defined as remuneration in any amount from commercial interests; grants; research support; consulting fees; salary; ownership interests [*e.g.*, stocks and stock options (excluding diversified mutual funds)]; honoraria and other payments for participation in speakers' bureaus, advisory boards, or boards of directors; and all other financial benefits. Completed forms are available through the Endocrine Society office.

The Endocrine Society provided the funding for this guideline; the task force received no funding or remuneration from commercial or other entities.

Commissioned Systematic Review

The task force commissioned two systematic reviews to support this guideline. The first one aimed to summarize the available evidence on the effect of sex steroid use in transgender individuals on lipids and cardiovascular outcomes. The review identified 29 eligible studies at moderate risk of bias. In transgender males (female to male), sex steroid therapy was associated with a statistically significant increase in serum triglycerides and low-density lipoprotein cholesterol levels. High-density lipoprotein cholesterol levels decreased significantly across all follow-up time periods. In transgender females (male to female), serum triglycerides were significantly higher without any changes in other parameters. Few myocardial infarction, stroke, venous thromboembolism (VTE), and death events were reported. These events were more frequent in transgender females. However, the quality of the evidence was low. The second review summarized the available evidence regarding the effect of sex steroids on bone health in transgender individuals and identified 13 studies. In transgender males, there was no statistically significant difference in the lumbar spine, femoral neck, or total hip BMD at 12 and 24 months compared with baseline values before initiating masculinizing hormone therapy. In transgender females, there was a statistically significant increase in lumbar spine BMD at 12 months and 24 months compared with baseline values before initiation of feminizing hormone therapy. There was minimal information on fracture rates. The quality of evidence was also low.

Introduction

Throughout recorded history (in the absence of an endocrine disorder) some men and women have experienced confusion and anguish resulting from rigid, forced conformity to sexual dimorphism. In modern history, there have been numerous ongoing biological, psychological, cultural, political, and sociological debates over various aspects of gender variance. The 20th century marked the emergence of a social awakening for men and women with the belief that they are "trapped" in the wrong body (3). Magnus Hirschfeld and Harry Benjamin, among others, pioneered the medical responses to those who sought relief from and a resolution to their profound discomfort. Although the term transsexual became widely known after Benjamin wrote "The Transsexual Phenomenon" (4), it was Hirschfeld who coined the term "transsexual" in 1923 to describe people who want to live a life that corresponds with their experienced gender vs their designated gender (5). Magnus Hirschfeld (6) and others (4, 7) have described other types of trans phenomena besides transsexualism. These early researchers proposed that the gender identity of these people was located somewhere along a unidimensional continuum. This continuum ranged from all male through "something in between" to all female. Yet such a classification does not take into account that people may have gender identities outside this continuum. For instance, some experience themselves as having both a male and female gender identity, whereas others completely renounce any gender classification (8, 9). There are also reports of individuals experiencing a continuous and rapid involuntary alternation between a male and female identity (10) or men who do not experience themselves as men but do not want to live as women (11, 12). In some countries, (*e.g.*, Nepal, Bangladesh, and Australia), these nonmale or nonfemale genders are officially recognized (13). Specific treatment protocols, however, have not yet been developed for these groups.

Instead of the term transsexualism, the current classification system of the American Psychiatric Association uses the term gender dysphoria in its diagnosis of persons who are not satisfied with their designated gender (14). The current version of the World Health Organization's ICD-10 still uses the term transsexualism when diagnosing adolescents and adults. However, for the ICD-11, the World Health Organization has proposed using the term "gender incongruence" (15).

Treating persons with GD/gender incongruence (15) was previously limited to relatively ineffective elixirs or creams. However, more effective endocrinology-based treatments became possible with the availability of testosterone in 1935 and diethylstilbestrol in 1938. Reports of individuals with GD/gender incongruence who were treated with hormones and gender-affirming surgery appeared in the press during the second half of the 20th century. The Harry Benjamin International Gender Dysphoria Association was founded in September 1979 and is now called the World Professional Association for Transgender Health (WPATH). WPATH published its first Standards of Care in 1979. These standards have since been regularly updated, providing guidance for treating persons with GD/gender incongruence (16).

Prior to 1975, few peer-reviewed articles were published concerning endocrine treatment of transgender persons. Since then, more than two thousand articles about various aspects of transgender care have appeared.

It is the purpose of this guideline to make detailed recommendations and suggestions, based on existing medical literature and clinical experience, that will enable treating physicians to maximize benefit and minimize risk when caring for individuals diagnosed with GD/gender incongruence.

In the future, we need more rigorous evaluations of the effectiveness and safety of endocrine and surgical protocols. Specifically, endocrine treatment protocols for GD/gender incongruence should include the careful assessment of the following: (1) the effects of prolonged delay of puberty in adolescents on bone health, gonadal function, and the brain (including effects on cognitive, emotional, social, and sexual development); (2) the effects of treatment in adults on sex hormone levels; (3) the requirement for and the effects of progestins and other agents used to suppress endogenous sex steroids during treatment; and (4) the risks and benefits of gender-affirming hormone treatment in older transgender people.

To successfully establish and enact these protocols, a commitment of mental health and endocrine investigators is required to collaborate in long-term, large-scale studies across countries that use the same diagnostic and inclusion criteria, medications, assay methods, and response assessment tools (*e.g.*, the European Network for the Investigation of Gender Incongruence) (17, 18).

Terminology and its use vary and continue to evolve. Table 1 contains the definitions of terms as they are used throughout this guideline.

Biological Determinants of Gender Identity Development

One's self-awareness as male or female changes gradually during infant life and childhood. This process of cognitive and affective learning evolves with interactions with parents, peers, and environment. A fairly accurate timetable exists outlining the steps in this process (19). Normative psychological literature, however, does not address if and when gender identity becomes crystallized and what factors contribute to the development of a gender identity that is not congruent with the gender of rearing. Results of studies from a variety of biomedical disciplines—genetic, endocrine, and neuroanatomic—support the concept that gender identity and/or gender expression (20) likely reflect a complex interplay of biological, environmental, and cultural factors (21, 22).

With respect to endocrine considerations, studies have failed to find differences in circulating levels of sex steroids between transgender and nontransgender individuals (23). However, studies in individuals with a disorder/difference of sex development (DSD) have informed our understanding of the role that hormones may play in gender identity outcome, even though most persons with GD/gender incongruence do not have a DSD. For example, although most 46,XX adult individuals with virilizing congenital adrenal hyperplasia caused by mutations in *CYP21A2* reported a female gender identity, the prevalence of GD/gender incongruence was much greater in this group than in the general population without a DSD. This supports the concept that there is a role for prenatal/postnatal androgens in gender development (24–26), although some studies indicate that prenatal androgens are more likely to affect gender behavior and sexual orientation rather than gender identity *per se* (27, 28).

Researchers have made similar observations regarding the potential role of androgens in the development of gender identity in other individuals with DSD. For example, a review of two groups of 46,XY persons, each with androgen synthesis deficiencies and female raised, reported transgender male (female-to-male) gender role changes in 56% to 63% and 39% to 64% of patients, respectively (29). Also, in 46,XY female-raised individuals with cloacal

doi: 10.1210/jc.2017-01658

Table 1. Definitions of Terms Used in This Guideline

Biological sex, biological male or female: These terms refer to physical aspects of maleness and femaleness. As these may not be in line with each other (*e.g.*, a person with XY chromosomes may have female-appearing genitalia), the terms biological sex and biological male or female are imprecise and should be avoided.

Cisgender: This means not transgender. An alternative way to describe individuals who are not transgender is "non-transgender people."

Gender-affirming (hormone) treatment: See "gender reassignment"

Gender dysphoria: This is the distress and unease experienced if gender identity and designated gender are not completely congruent (see Table 2). In 2013, the American Psychiatric Association released the fifth edition of the DSM-5, which replaced "gender identity disorder" with "gender dysphoria" and changed the criteria for diagnosis.

Gender expression: This refers to external manifestations of gender, expressed through one's name, pronouns, clothing, haircut, behavior, voice, or body characteristics. Typically, transgender people seek to make their gender expression align with their gender identity, rather than their designated gender.

Gender identity/experienced gender: This refers to one's internal, deeply held sense of gender. For transgender people, their gender identity does not match their sex designated at birth. Most people have a gender identity of man or woman (or boy or girl). For some people, their gender identity does not fit neatly into one of those two choices. Unlike gender expression (see below), gender identity is not visible to others.

Gender identity disorder: This is the term used for GD/gender incongruence in previous versions of DSM (see "gender dysphoria"). The ICD-10 still uses the term for diagnosing child diagnoses, but the upcoming ICD-11 has proposed using "gender incongruence of childhood."

Gender incongruence: This is an umbrella term used when the gender identity and/or gender expression differs from what is typically associated with the designated gender. Gender incongruence is also the proposed name of the gender identity–related diagnoses in ICD-11. Not all individuals with gender incongruence have gender dysphoria or seek treatment.

Gender variance: See "gender incongruence"

Gender reassignment: This refers to the treatment procedure for those who want to adapt their bodies to the experienced gender by means of hormones and/or surgery. This is also called gender-confirming or gender-affirming treatment.

Gender-reassignment surgery (gender-confirming/gender-affirming surgery): These terms refer only to the surgical part of gender-confirming/gender-affirming treatment.

Gender role: This refers to behaviors, attitudes, and personality traits that a society (in a given culture and historical period) designates as masculine or feminine and/or that society associates with or considers typical of the social role of men or women.

Sex designated at birth: This refers to sex assigned at birth, usually based on genital anatomy.

Sex: This refers to attributes that characterize biological maleness or femaleness. The best known attributes include the sex-determining genes, the sex chromosomes, the H-Y antigen, the gonads, sex hormones, internal and external genitalia, and secondary sex characteristics.

Sexual orientation: This term describes an individual's enduring physical and emotional attraction to another person. Gender identity and sexual orientation are not the same. Irrespective of their gender identity, transgender people may be attracted to women (gynephilic), attracted to men (androphilic), bisexual, asexual, or queer.

Transgender: This is an umbrella term for people whose gender identity and/or gender expression differs from what is typically associated with their sex designated at birth. Not all transgender individuals seek treatment.

Transgender male (also: trans man, female-to-male, transgender male): This refers to individuals assigned female at birth but who identify and live as men.

Transgender woman (also: trans woman, male-to female, transgender female): This refers to individuals assigned male at birth but who identify and live as women.

Transition: This refers to the process during which transgender persons change their physical, social, and/or legal characteristics consistent with the affirmed gender identity. Prepubertal children may choose to transition socially.

Transsexual: This is an older term that originated in the medical and psychological communities to refer to individuals who have permanently transitioned through medical interventions or desired to do so.

exstrophy and penile agenesis, the occurrence of transgender male changes was significantly more prevalent than in the general population (30, 31). However, the fact that a high percentage of individuals with the same conditions did not change gender suggests that cultural factors may play a role as well.

With respect to genetics and gender identity, several studies have suggested heritability of GD/gender incongruence (32, 33). In particular, a study by Heylens *et al.* (33) demonstrated a 39.1% concordance rate for gender identity disorder (based on the DSM-IV criteria) in 23 monozygotic twin pairs but no concordance in 21 same-sex dizygotic or seven opposite-sex twin pairs. Although numerous investigators have sought to identify specific genes associated with GD/gender incongruence, such studies have been inconsistent and without strong statistical significance (34–38).

Studies focusing on brain structure suggest that the brain phenotypes of people with GD/gender incongruence differ in various ways from control males and females, but that there is not a complete sex reversal in brain structures (39).

In summary, although there is much that is still unknown with respect to gender identity and its expression, compelling studies support the concept that biologic factors, in addition to environmental factors, contribute to this fundamental aspect of human development.

Natural History of Children With GD/Gender Incongruence

With current knowledge, we cannot predict the psychosexual outcome for any specific child. Prospective follow-up studies show that childhood GD/gender incongruence does not invariably persist into adolescence and adulthood (so-called "desisters"). Combining all outcome studies to date, the GD/gender incongruence of a minority of prepubertal children appears to persist in adolescence (20, 40). In adolescence, a significant number of these desisters identify as homosexual or bisexual. It may be that children who only showed some gender nonconforming characteristics have been included in the follow-up studies, because the DSM-IV text revision criteria for a diagnosis were rather broad. However, the persistence of GD/gender incongruence into adolescence is more likely if it had been extreme in childhood (41, 42). With the newer, stricter criteria of the DSM-5 (Table 2), persistence rates may well be different in future studies.

1.0 Evaluation of Youth and Adults

Gender-affirming treatment is a multidisciplinary effort. After evaluation, education, and diagnosis, treatment may include mental health care, hormone therapy, and/or surgical therapy. Together with an MHP, hormone-prescribing clinicians should examine the psychosocial impact of the potential changes on people's lives, including mental health, friends, family, jobs, and their role in society. Transgender individuals should be encouraged to experience living in the new gender role and assess whether this improves their quality of life. Although the focus of this guideline is gender-affirming hormone therapy, collaboration with appropriate professionals responsible for each aspect of treatment maximizes a successful outcome.

Diagnostic assessment and mental health care

GD/gender incongruence may be accompanied with psychological or psychiatric problems (43–51). It is therefore necessary that clinicians who prescribe hormones and are involved in diagnosis and psychosocial assessment meet the following criteria: (1) are competent in using the DSM and/or the ICD for diagnostic purposes, (2) are able to diagnose GD/gender incongruence and make a distinction between GD/gender incongruence and conditions that have similar features (*e.g.*, body dysmorphic disorder), (3) are trained in diagnosing psychiatric conditions, (4) undertake or refer for appropriate treatment, (5) are able to do a psychosocial assessment of the patient's understanding, mental health, and social conditions that can impact gender-affirming hormone therapy, and (6) regularly attend relevant professional meetings.

Because of the psychological vulnerability of many individuals with GD/gender incongruence, it is important that mental health care is available before, during, and sometimes also after transitioning. For children and adolescents, an MHP who has training/experience in child and adolescent gender development (as well as child and adolescent psychopathology) should make the diagnosis, because assessing GD/gender incongruence in children and adolescents is often extremely complex.

During assessment, the clinician obtains information from the individual seeking gender-affirming treatment. In the case

Table 2. DSM-5 Criteria for Gender Dysphoria in Adolescents and Adults

A. A marked incongruence between one's experienced/expressed gender and natal gender of at least 6 mo in duration, as manifested by at least two of the following:
   1. A marked incongruence between one's experienced/expressed gender and primary and/or secondary sex characteristics (or in young adolescents, the anticipated secondary sex characteristics)
   2. A strong desire to be rid of one's primary and/or secondary sex characteristics because of a marked incongruence with one's experienced/expressed gender (or in young adolescents, a desire to prevent the development of the anticipated secondary sex characteristics)
   3. A strong desire for the primary and/or secondary sex characteristics of the other gender
   4. A strong desire to be of the other gender (or some alternative gender different from one's designated gender)
   5. A strong desire to be treated as the other gender (or some alternative gender different from one's designated gender)
   6. A strong conviction that one has the typical feelings and reactions of the other gender (or some alternative gender different from one's designated gender)

B. The condition is associated with clinically significant distress or impairment in social, occupational, or other important areas of functioning.

Specify if:
   1. The condition exists with a disorder of sex development.
   2. The condition is posttransitional, in that the individual has transitioned to full-time living in the desired gender (with or without legalization of gender change) and has undergone (or is preparing to have) at least one sex-related medical procedure or treatment regimen—namely, regular sex hormone treatment or gender reassignment surgery confirming the desired gender (*e.g.*, penectomy, vaginoplasty in natal males; mastectomy or phalloplasty in natal females).

Reference: American Psychiatric Association (14).

doi: 10.1210/jc.2017-01658

of adolescents, the clinician also obtains information from the parents or guardians regarding various aspects of the child's general and psychosexual development and current functioning. On the basis of this information, the clinician:

- decides whether the individual fulfills criteria for treatment (see Tables 2 and 3) for GD/gender incongruence (DSM-5) or transsexualism (DSM-5 and/or ICD-10);
- informs the individual about the possibilities and limitations of various kinds of treatment (hormonal/surgical and nonhormonal), and if medical treatment is desired, provides correct information to prevent unrealistically high expectations;
- assesses whether medical interventions may result in unfavorable psychological and social outcomes.

In cases in which severe psychopathology, circumstances, or both seriously interfere with the diagnostic work or make satisfactory treatment unlikely, clinicians should assist the adolescent in managing these other issues. Literature on postoperative regret suggests that besides poor quality of surgery, severe psychiatric comorbidity and lack of support may interfere with positive outcomes (52–56).

For adolescents, the diagnostic procedure usually includes a complete psychodiagnostic assessment (57) and an assessment of the decision-making capability of the youth. An evaluation to assess the family's ability to endure stress, give support, and deal with the complexities of the adolescent's situation should be part of the diagnostic phase (58).

Social transitioning

A change in gender expression and role (which may involve living part time or full time in another gender role that is consistent with one's gender identity) may test the person's resolve, the capacity to function in the affirmed gender, and the adequacy of social, economic, and psychological supports. It assists both the individual and the clinician in their judgments about how to proceed (16). During social transitioning, the person's feelings about the social transformation (including coping with the responses of others) is a major focus of the counseling. The optimal timing for social transitioning may differ between individuals. Sometimes people wait until they start gender-affirming hormone treatment to make social transitioning easier, but individuals increasingly start social transitioning long before they receive medically supervised, gender-affirming hormone treatment.

Criteria

Adolescents and adults seeking gender-affirming hormone treatment and surgery should satisfy certain criteria before proceeding (16). Criteria for gender-affirming hormone therapy for adults are in Table 4, and criteria for gender-affirming hormone therapy for adolescents are in Table 5. Follow-up studies in adults meeting these criteria indicate a high satisfaction rate with treatment (59). However, the quality of evidence is usually low. A few follow-up studies on adolescents who fulfilled these criteria also indicated good treatment results (60–63).

Recommendations for Those Involved in the Gender-Affirming Hormone Treatment of Individuals With GD/Gender Incongruence

1.1. We advise that only trained MHPs who meet the following criteria should diagnose GD/gender incongruence in adults: (1) competence in using the DSM and/or the ICD for diagnostic purposes, (2) the ability to diagnose GD/gender incongruence and make a distinction between GD/gender incongruence and conditions that have similar features (*e.g.*, body dysmorphic disorder), (3) training in diagnosing psychiatric conditions, (4) the ability to undertake or refer for appropriate treatment, (5) the ability to psychosocially assess the person's understanding, mental health, and social conditions that can impact gender-affirming hormone therapy, and (6) a practice of regularly attending relevant professional meetings. (Ungraded Good Practice Statement)

1.2. We advise that only MHPs who meet the following criteria should diagnose GD/gender incongruence in children and adolescents: (1) training in child and adolescent developmental psychology and psychopathology, (2) competence in using the DSM and/or ICD for diagnostic

Table 3. ICD-10 Criteria for Transsexualism

Transsexualism (F64.0) has three criteria:
1. The desire to live and be accepted as a member of the opposite sex, usually accompanied by the wish to make his or her body as congruent as possible with the preferred sex through surgery and hormone treatments.
2. The transsexual identity has been present persistently for at least 2 y.
3. The disorder is not a symptom of another mental disorder or a genetic, DSD, or chromosomal abnormality.

Table 4. Criteria for Gender-Affirming Hormone Therapy for Adults

1. Persistent, well-documented gender dysphoria/gender incongruence
2. The capacity to make a fully informed decision and to consent for treatment
3. The age of majority in a given country (if younger, follow the criteria for adolescents)
4. Mental health concerns, if present, must be reasonably well controlled

Reproduced from World Professional Association for Transgender Health (16).

purposes, (3) the ability to make a distinction between GD/gender incongruence and conditions that have similar features (*e.g.*, body dysmorphic disorder), (4) training in diagnosing psychiatric conditions, (5) the ability to undertake or refer for appropriate treatment, (6) the ability to psychosocially assess the person's understanding and social conditions that can impact gender-affirming hormone therapy, (7) a practice of regularly attending relevant professional meetings, and (8) knowledge of the criteria for puberty blocking and gender-affirming hormone treatment in adolescents. (Ungraded Good Practice Statement)

Evidence

Individuals with gender identity issues may have psychological or psychiatric problems (43–48, 50, 51, 64, 65). It is therefore necessary that clinicians making the diagnosis are able to make a distinction between GD/gender incongruence and conditions that have similar features. Examples of conditions with similar features are body dysmorphic disorder, body identity integrity disorder (a condition in which individuals have a sense that their anatomical configuration as an able-bodied person is somehow wrong or inappropriate) (66), or certain forms of eunuchism (in which a person is preoccupied with or engages in castration and/or penectomy for

Table 5. Criteria for Gender-Affirming Hormone Therapy for Adolescents

Adolescents are eligible for GnRH agonist treatment if:

1. A qualified MHP has confirmed that:
- the adolescent has demonstrated a long-lasting and intense pattern of gender nonconformity or gender dysphoria (whether suppressed or expressed),
- gender dysphoria worsened with the onset of puberty,
- any coexisting psychological, medical, or social problems that could interfere with treatment (*e.g.*, that may compromise treatment adherence) have been addressed, such that the adolescent's situation and functioning are stable enough to start treatment,
- the adolescent has sufficient mental capacity to give informed consent to this (reversible) treatment,

2. And the adolescent:
- has been informed of the effects and side effects of treatment (including potential loss of fertility if the individual subsequently continues with sex hormone treatment) and options to preserve fertility,
- has given informed consent and (particularly when the adolescent has not reached the age of legal medical consent, depending on applicable legislation) the parents or other caretakers or guardians have consented to the treatment and are involved in supporting the adolescent throughout the treatment process,

3. And a pediatric endocrinologist or other clinician experienced in pubertal assessment
- agrees with the indication for GnRH agonist treatment,
- has confirmed that puberty has started in the adolescent (Tanner stage ≥G2/B2),
- has confirmed that there are no medical contraindications to GnRH agonist treatment.

Adolescents are eligible for subsequent sex hormone treatment if:

1. A qualified MHP has confirmed:
- the persistence of gender dysphoria,
- any coexisting psychological, medical, or social problems that could interfere with treatment (*e.g.*, that may compromise treatment adherence) have been addressed, such that the adolescent's situation and functioning are stable enough to start sex hormone treatment,
- the adolescent has sufficient mental capacity (which most adolescents have by age 16 years) to estimate the consequences of this (partly) irreversible treatment, weigh the benefits and risks, and give informed consent to this (partly) irreversible treatment,

2. And the adolescent:
- has been informed of the (irreversible) effects and side effects of treatment (including potential loss of fertility and options to preserve fertility),
- has given informed consent and (particularly when the adolescent has not reached the age of legal medical consent, depending on applicable legislation) the parents or other caretakers or guardians have consented to the treatment and are involved in supporting the adolescent throughout the treatment process,

3. And a pediatric endocrinologist or other clinician experienced in pubertal induction:
- agrees with the indication for sex hormone treatment,
- has confirmed that there are no medical contraindications to sex hormone treatment.

Reproduced from World Professional Association for Transgender Health (16).

doi: 10.1210/jc.2017-01658

reasons that are not gender identity related) (11). Clinicians should also be able to diagnose psychiatric conditions accurately and ensure that these conditions are treated appropriately, particularly when the conditions may complicate treatment, affect the outcome of gender-affirming treatment, or be affected by hormone use.

Values and preferences

The task force placed a very high value on avoiding harm from hormone treatment in individuals who have conditions other than GD/gender incongruence and who may not benefit from the physical changes associated with this treatment and placed a low value on any potential benefit these persons believe they may derive from hormone treatment. This justifies the good practice statement.

1.3. We advise that decisions regarding the social transition of prepubertal youths with GD/gender incongruence are made with the assistance of an MHP or another experienced professional. (Ungraded Good Practice Statement).

1.4. We recommend against puberty blocking and gender-affirming hormone treatment in prepubertal children with GD/gender incongruence. (1 |⊕⊕◯◯)

Evidence

In most children diagnosed with GD/gender incongruence, it did not persist into adolescence. The percentages differed among studies, probably dependent on which version of the DSM clinicians used, the patient's age, the recruitment criteria, and perhaps cultural factors. However, the large majority (about 85%) of prepubertal children with a childhood diagnosis did not remain GD/gender incongruent in adolescence (20). If children have completely socially transitioned, they may have great difficulty in returning to the original gender role upon entering puberty (40). Social transition is associated with the persistence of GD/gender incongruence as a child progresses into adolescence. It may be that the presence of GD/gender incongruence in prepubertal children is the earliest sign that a child is destined to be transgender as an adolescent/adult (20). However, social transition (in addition to GD/gender incongruence) has been found to contribute to the likelihood of persistence.

This recommendation, however, does not imply that children should be discouraged from showing gender-variant behaviors or should be punished for exhibiting such behaviors. In individual cases, an early complete social transition may result in a more favorable outcome, but there are currently no criteria to identify the GD/gender-incongruent children to whom this applies. At the present time, clinical experience suggests that persistence of GD/gender incongruence can only be reliably assessed after the first signs of puberty.

Values and preferences

The task force placed a high value on avoiding harm with gender-affirming hormone therapy in prepubertal children with GD/gender incongruence. This justifies the strong recommendation in the face of low-quality evidence.

1.5. We recommend that clinicians inform and counsel all individuals seeking gender-affirming medical treatment regarding options for fertility preservation prior to initiating puberty suppression in adolescents and prior to treating with hormonal therapy of the affirmed gender in both adolescents and adults. (1 |⊕⊕⊕◯)

Remarks

Persons considering hormone use for gender affirmation need adequate information about this treatment in general and about fertility effects of hormone treatment in particular to make an informed and balanced decision (67, 68). Because young adolescents may not feel qualified to make decisions about fertility and may not fully understand the potential effects of hormonal interventions, consent and protocol education should include parents, the referring MHP(s), and other members of the adolescent's support group. To our knowledge, there are no formally evaluated decision aids available to assist in the discussion and decision regarding the future fertility of adolescents or adults beginning gender-affirming treatment.

Treating early pubertal youth with GnRH analogs will temporarily impair spermatogenesis and oocyte maturation. Given that an increasing number of transgender youth want to preserve fertility potential, delaying or temporarily discontinuing GnRH analogs to promote gamete maturation is an option. This option is often not preferred, because mature sperm production is associated with later stages of puberty and with the significant development of secondary sex characteristics.

For those designated male at birth with GD/gender incongruence and who are in early puberty, sperm production and the development of the reproductive tract are insufficient for the cryopreservation of sperm. However, prolonged pubertal suppression using GnRH analogs is reversible and clinicians should inform these individuals that sperm production can be initiated following prolonged gonadotropin suppression. This can be accomplished by spontaneous gonadotropin recovery after

cessation of GnRH analogs or by gonadotropin treatment and will probably be associated with physical manifestations of testosterone production, as stated above. Note that there are no data in this population concerning the time required for sufficient spermatogenesis to collect enough sperm for later fertility. In males treated for precocious puberty, spermarche was reported 0.7 to 3 years after cessation of GnRH analogs (69). In adult men with gonadotropin deficiency, sperm are noted in seminal fluid by 6 to 12 months of gonadotropin treatment. However, sperm numbers when partners of these patients conceive are far below the "normal range" (70, 71).

In girls, no studies have reported long-term, adverse effects of pubertal suppression on ovarian function after treatment cessation (72, 73). Clinicians should inform adolescents that no data are available regarding either time to spontaneous ovulation after cessation of GnRH analogs or the response to ovulation induction following prolonged gonadotropin suppression.

In males with GD/gender incongruence, when medical treatment is started in a later phase of puberty or in adulthood, spermatogenesis is sufficient for cryopreservation and storage of sperm. *In vitro* spermatogenesis is currently under investigation. Restoration of spermatogenesis after prolonged estrogen treatment has not been studied.

In females with GD/gender incongruence, the effect of prolonged treatment with exogenous testosterone on ovarian function is uncertain. There have been reports of an increased incidence of polycystic ovaries in transgender males, both prior to and as a result of androgen treatment (74–77), although these reports were not confirmed by others (78). Pregnancy has been reported in transgender males who have had prolonged androgen treatment and have discontinued testosterone but have not had genital surgery (79, 80). A reproductive endocrine gynecologist can counsel patients before gender-affirming hormone treatment or surgery regarding potential fertility options (81). Techniques for cryopreservation of oocytes, embryos, and ovarian tissue continue to improve, and oocyte maturation of immature tissue is being studied (82).

2.0 Treatment of Adolescents

During the past decade, clinicians have progressively acknowledged the suffering of young adolescents with GD/gender incongruence. In some forms of GD/gender incongruence, psychological interventions may be useful and sufficient. However, for many adolescents with GD/gender incongruence, the pubertal physical changes are unbearable. As early medical intervention may prevent psychological harm, various clinics have decided to start treating young adolescents with GD/gender incongruence with puberty-suppressing medication (a GnRH analog). As compared with starting gender-affirming treatment long after the first phases of puberty, a benefit of pubertal suppression at early puberty may be a better psychological and physical outcome.

In girls, the first physical sign of puberty is the budding of the breasts followed by an increase in breast and fat tissue. Breast development is also associated with the pubertal growth spurt, and menarche occurs ~2 years later. In boys, the first physical change is testicular growth. A testicular volume ≥4 mL is seen as consistent with the initiation of physical puberty. At the beginning of puberty, estradiol and testosterone levels are still low and are best measured in the early morning with an ultrasensitive assay. From a testicular volume of 10 mL, daytime testosterone levels increase, leading to virilization (83). Note that pubic hair and/or axillary hair/odor may not reflect the onset of gonadarche; instead, it may reflect adrenarche alone.

2.1. We suggest that adolescents who meet diagnostic criteria for GD/gender incongruence, fulfill criteria for treatment (Table 5), and are requesting treatment should initially undergo treatment to suppress pubertal development. (2 ⊕⊕◯◯)

2.2. We suggest that clinicians begin pubertal hormone suppression after girls and boys first exhibit physical changes of puberty (Tanner stages G2/B2). (2 ⊕⊕◯◯)

Evidence

Pubertal suppression can expand the diagnostic phase by a long period, giving the subject more time to explore options and to live in the experienced gender before making a decision to proceed with gender-affirming sex hormone treatments and/or surgery, some of which is irreversible (84, 85). Pubertal suppression is fully reversible, enabling full pubertal development in the natal gender, after cessation of treatment, if appropriate. The experience of full endogenous puberty is an undesirable condition for the GD/gender-incongruent individual and may seriously interfere with healthy psychological functioning and well-being. Treating GD/gender-incongruent adolescents entering puberty with GnRH analogs has been shown to improve psychological functioning in several domains (86).

Another reason to start blocking pubertal hormones early in puberty is that the physical outcome is improved compared with initiating physical transition after puberty has been completed (60, 62). Looking like a man or woman when living as the opposite sex creates difficult

doi: 10.1210/jc.2017-01658

barriers with enormous life-long disadvantages. We therefore advise starting suppression in early puberty to prevent the irreversible development of undesirable secondary sex characteristics. However, adolescents with GD/gender incongruence should experience the first changes of their endogenous spontaneous puberty, because their emotional reaction to these first physical changes has diagnostic value in establishing the persistence of GD/gender incongruence (85). Thus, Tanner stage 2 is the optimal time to start pubertal suppression. However, pubertal suppression treatment in early puberty will limit the growth of the penis and scrotum, which will have a potential effect on future surgical treatments (87).

Clinicians can also use pubertal suppression in adolescents in later pubertal stages to stop menses in transgender males and prevent facial hair growth in transgender females. However, in contrast to the effects in early pubertal adolescents, physical sex characteristics (such as more advanced breast development in transgender boys and lowering of the voice and outgrowth of the jaw and brow in transgender girls) are not reversible.

Values and preferences

These recommendations place a high value on avoiding an unsatisfactory physical outcome when secondary sex characteristics have become manifest and irreversible, a higher value on psychological well-being, and a lower value on avoiding potential harm from early pubertal suppression.

Remarks

Table 6 lists the Tanner stages of breast and male genital development. Careful documentation of hallmarks of pubertal development will ensure precise timing when initiating pubertal suppression once puberty has started. Clinicians can use pubertal LH and sex steroid levels to confirm that puberty has progressed sufficiently before starting pubertal suppression (88). Reference ranges for sex steroids by Tanner stage may vary depending on the assay used. Ultrasensitive sex steroid and gonadotropin assays will help clinicians document early pubertal changes.

Irreversible and, for GD/gender-incongruent adolescents, undesirable sex characteristics in female puberty are breasts, female body habitus, and, in some cases, relative short stature. In male puberty, they are a prominent Adam's apple; low voice; male bone configuration, such as a large jaw, big feet and hands, and tall stature; and male hair pattern on the face and extremities.

2.3. We recommend that, where indicated, GnRH analogues are used to suppress pubertal hormones. (1 ⊕⊕◯◯)

Evidence

Clinicians can suppress pubertal development and gonadal function most effectively via gonadotropin suppression using GnRH analogs. GnRH analogs are long-acting agonists that suppress gonadotropins by GnRH receptor desensitization after an initial increase of gonadotropins during ~10 days after the first and (to a lesser degree) the second injection (89). Antagonists immediately suppress pituitary gonadotropin secretion (90, 91). Long-acting GnRH analogs are the currently preferred treatment option. Clinicians may consider long-acting GnRH antagonists when evidence on their safety and efficacy in adolescents becomes available.

During GnRH analog treatment, slight development of secondary sex characteristics may regress, and in a later phase of pubertal development, it will stop. In girls, breast tissue will become atrophic, and menses will stop. In boys, virilization will stop, and testicular volume may decrease (92).

An advantage of using GnRH analogs is the reversibility of the intervention. If, after extensive exploration of his/her transition wish, the individual no longer desires transition, they can discontinue pubertal suppression. In subjects with

Table 6. Tanner Stages of Breast Development and Male External Genitalia

The description of Tanner stages for breast development:
1. Prepubertal
2. Breast and papilla elevated as small mound; areolar diameter increased
3. Breast and areola enlarged, no contour separation
4. Areola and papilla form secondary mound
5. Mature; nipple projects, areola part of general breast contour

For penis and testes:
1. Prepubertal, testicular volume <4 mL
2. Slight enlargement of penis; enlarged scrotum, pink, texture altered, testes 4–6 mL
3. Penis longer, testes larger (8–12 mL)
4. Penis and glans larger, including increase in breadth; testes larger (12–15 mL), scrotum dark
5. Penis adult size; testicular volume > 15 ml

Adapted from Lawrence (56).

precocious puberty, spontaneous pubertal development has been shown to resume after patients discontinue taking GnRH analogs (93).

Recommendations 2.1 to 2.3 are supported by a prospective follow-up study from The Netherlands. This report assessed mental health outcomes in 55 transgender adolescents/young adults (22 transgender females and 33 transgender males) at three time points: (1) before the start of GnRH agonist (average age of 14.8 years at start of treatment), (2) at initiation of gender-affirming hormones (average age of 16.7 years at start of treatment), and (3) 1 year after "gender-reassignment surgery" (average age of 20.7 years) (63). Despite a decrease in depression and an improvement in general mental health functioning, GD/gender incongruence persisted through pubertal suppression, as previously reported (86). However, following sex hormone treatment and gender-reassignment surgery, GD/gender incongruence was resolved and psychological functioning steadily improved (63). Furthermore, well-being was similar to or better than that reported by age-matched young adults from the general population, and none of the study participants regretted treatment. This study represents the first long-term follow-up of individuals managed according to currently existing clinical practice guidelines for transgender youth, and it underscores the benefit of the multidisciplinary approach pioneered in The Netherlands; however, further studies are needed.

Side effects

The primary risks of pubertal suppression in GD/gender-incongruent adolescents may include adverse effects on bone mineralization (which can theoretically be reversed with sex hormone treatment), compromised fertility if the person subsequently is treated with sex hormones, and unknown effects on brain development. Few data are available on the effect of GnRH analogs on BMD in adolescents with GD/gender incongruence. Initial data in GD/gender-incongruent subjects demonstrated no change of absolute areal BMD during 2 years of GnRH analog therapy but a decrease in BMD *z* scores (85). A recent study also suggested suboptimal bone mineral accrual during GnRH analog treatment. The study reported a decrease in areal BMD *z* scores and of bone mineral apparent density *z* scores (which takes the size of the bone into account) in 19 transgender males treated with GnRH analogs from a mean age of 15.0 years (standard deviation = 2.0 years) for a median duration of 1.5 years (0.3 to 5.2 years) and in 15 transgender females treated from 14.9 (±1.9) years for 1.3 years (0.5 to 3.8 years), although not all changes were statistically significant (94). There was incomplete catch-up at age 22 years after sex hormone treatment from age 16.6 (±1.4) years for a median duration of 5.8 years (3.0 to 8.0 years) in transgender females and from age 16.4 (±2.3) years for 5.4 years (2.8 to 7.8 years) in transgender males. Little is known about more prolonged use of GnRH analogs. Researchers reported normal BMD *z* scores at age 35 years in one individual who used GnRH analogs from age 13.7 years until age 18.6 years before initiating sex hormone treatment (65).

Additional data are available from individuals with late puberty or GnRH analog treatment of other indications. Some studies reported that men with constitutionally delayed puberty have decreased BMD in adulthood (95). However, other studies reported that these men have normal BMD (96, 97). Treating adults with GnRH analogs results in a decrease of BMD (98). In children with central precocious puberty, treatment with GnRH analogs has been found to result in a decrease of BMD during treatment by some (99) but not others (100). Studies have reported normal BMD after discontinuing therapy (69, 72, 73, 101, 102). In adolescents treated with growth hormone who are small for gestational age and have normal pubertal timing, 2-year GnRH analog treatments did not adversely affect BMD (103). Calcium supplementation may be beneficial in optimizing bone health in GnRH analog–treated individuals (104). There are no studies of vitamin D supplementation in this context, but clinicians should offer supplements to vitamin D–deficient adolescents. Physical activity, especially during growth, is important for bone mass in healthy individuals (103) and is therefore likely to be beneficial for bone health in GnRH analog–treated subjects.

GnRH analogs did not induce a change in body mass index standard deviation score in GD/gender-incongruent adolescents (94) but caused an increase in fat mass and decrease in lean body mass percentage (92). Studies in girls treated for precocious puberty also reported a stable body mass index standard deviation score during treatment (72) and body mass index and body composition comparable to controls after treatment (73).

Arterial hypertension has been reported as an adverse effect in a few girls treated with GnRH analogs for precocious/early puberty (105, 106). Blood pressure monitoring before and during treatment is recommended.

Individuals may also experience hot flashes, fatigue, and mood alterations as a consequence of pubertal suppression. There is no consensus on treatment of these side effects in this context.

It is recommended that any use of pubertal blockers (and subsequent use of sex hormones, as detailed below) include a discussion about implications for fertility (see recommendation 1.3). Transgender adolescents may

doi: 10.1210/jc.2017-01658

want to preserve fertility, which may be otherwise compromised if puberty is suppressed at an early stage and the individual completes phenotypic transition with the use of sex hormones.

Limited data are available regarding the effects of GnRH analogs on brain development. A single cross-sectional study demonstrated no compromise of executive function (107), but animal data suggest there may be an effect of GnRH analogs on cognitive function (108).

Values and preferences

Our recommendation of GnRH analogs places a higher value on the superior efficacy, safety, and reversibility of the pubertal hormone suppression achieved (as compared with the alternatives) and a relatively lower value on limiting the cost of therapy. Of the available alternatives, depot and oral progestin preparations are effective. Experience with this treatment dates back prior to the emergence of GnRH analogs for treating precocious puberty in papers from the 1960s and early 1970s (109–112). These compounds are usually safe, but some side effects have been reported (113–115). Only two recent studies involved transgender youth (116, 117). One of these studies described the use of oral lynestrenol monotherapy followed by the addition of testosterone treatment in transgender boys who were at Tanner stage B4 or further at the start of treatment (117). They found lynestrenol safe, but gonadotropins were not fully suppressed. The study reported metrorrhagia in approximately half of the individuals, mainly in the first 6 months. Acne, headache, hot flashes, and fatigue were other frequent side effects. Another progestin that has been studied in the United States is medroxyprogesterone. This agent is not as effective as GnRH analogs in lowering endogenous sex hormones either and may be associated with other side effects (116). Progestin preparations may be an acceptable treatment for persons without access to GnRH analogs or with a needle phobia. If GnRH analog treatment is not available (insurance denial, prohibitive cost, or other reasons), postpubertal, transgender female adolescents may be treated with an antiandrogen that directly suppresses androgen synthesis or action (see adult section).

Remarks

Measurements of gonadotropin and sex steroid levels give precise information about gonadal axis suppression, although there is insufficient evidence for any specific short-term monitoring scheme in children treated with GnRH analogs (88). If the gonadal axis is not completely suppressed—as evidenced by (for example) menses, erections, or progressive hair growth—the interval of GnRH analog treatment can be shortened or the dose increased. During treatment, adolescents should be monitored for negative effects of delaying puberty, including a halted growth spurt and impaired bone mineral accretion. Table 7 illustrates a suggested clinical protocol.

Anthropometric measurements and X-rays of the left hand to monitor bone age are informative for evaluating growth. To assess BMD, clinicians can perform dual-energy X-ray absorptiometry scans.

2.4. In adolescents who request sex hormone treatment (given this is a partly irreversible treatment), we recommend initiating treatment using a gradually increasing dose schedule (see Table 8) after a multidisciplinary team of medical and MHPs has confirmed the persistence of GD/gender incongruence and sufficient mental capacity to give informed consent, which most adolescents have by age 16 years (Table 5). (1 |⊕⊕◯◯)

2.5. We recognize that there may be compelling reasons to initiate sex hormone treatment prior to the age of 16 years in some adolescents with GD/gender incongruence, even though there are minimal published studies of gender-affirming hormone treatments administered before age 13.5 to 14 years. As with the care of adolescents ≥16 years of age, we recommend that an expert multidisciplinary team of medical and MHPs manage this treatment. (1 |⊕◯◯◯)

2.6. We suggest monitoring clinical pubertal development every 3 to 6 months and laboratory parameters every 6 to 12 months during sex hormone treatment (Table 9). (2 |⊕⊕◯◯)

Table 7. Baseline and Follow-Up Protocol During Suppression of Puberty

Every 3–6 mo
Anthropometry: height, weight, sitting height, blood pressure, Tanner stages
Every 6–12 mo
Laboratory: LH, FSH, E2/T, 25OH vitamin D
Every 1–2 y
Bone density using DXA
Bone age on X-ray of the left hand (if clinically indicated)

Adapted from Hembree *et al.* (118).

Abbreviations: DXA, dual-energy X-ray absorptiometry; E2, estradiol; FSH, follicle stimulating hormone; LH, luteinizing hormone; T, testosterone;

Table 8. Protocol Induction of Puberty

Induction of female puberty with oral 17β-estradiol, increasing the dose every 6 mo:
- 5 μg/kg/d
- 10 μg/kg/d
- 15 μg/kg/d
- 20 μg/kg/d
- Adult dose = 2–6 mg/d
- *In postpubertal transgender female adolescents, the dose of 17β-estradiol can be increased more rapidly:*
  - 1 mg/d for 6 mo
  - 2 mg/d

Induction of female puberty with transdermal 17β-estradiol, increasing the dose every 6 mo (new patch is placed every 3.5 d):
- 6.25–12.5 μg/24 h (cut 25-μg patch into quarters, then halves)
- 25 μg/24 h
- 37.5 μg/24 h
- Adult dose = 50–200 μg/24 h
- *For alternatives once at adult dose, see Table 11.*
- *Adjust maintenance dose to mimic physiological estradiol levels (see Table 15).*

Induction of male puberty with testosterone esters increasing the dose every 6 mo (IM or SC):
- 25 mg/m^2/2 wk (or alternatively, half this dose weekly, or double the dose every 4 wk)
- 50 mg/m^2/2 wk
- 75 mg/m^2/2 wk
- 100 mg/m^2/2 wk
- Adult dose = 100–200 mg every 2 wk
- *In postpubertal transgender male adolescents the dose of testosterone esters can be increased more rapidly:*
  - 75 mg/2 wk for 6 mo
  - 125 mg/2 wk
- *For alternatives once at adult dose, see Table 11.*
- *Adjust maintenance dose to mimic physiological testosterone levels (see Table 14).*

Adapted from Hembree *et al.* (118).

Abbreviations: IM, intramuscularly; SC, subcutaneously.

Evidence

Adolescents develop competence in decision making at their own pace. Ideally, the supervising medical professionals should individually assess this competence, although no objective tools to make such an assessment are currently available.

Many adolescents have achieved a reasonable level of competence by age 15 to 16 years (119), and in many countries 16-year-olds are legally competent with regard to medical decision making (120). However, others believe that although some capacities are generally achieved before age 16 years, other abilities (such as good risk assessment) do not develop until well after 18 years (121). They suggest that health care procedures should be divided along a matrix of relative risk, so that younger adolescents can be allowed to decide about low-risk procedures, such as most diagnostic tests and common therapies, but not about high-risk procedures, such as most surgical procedures (121).

Currently available data from transgender adolescents support treatment with sex hormones starting at age 16 years (63, 122). However, some patients may incur potential risks by waiting until age 16 years. These include the potential risk to bone health if puberty is suppressed

Table 9. Baseline and Follow-up Protocol During Induction of Puberty

Every 3–6 mo
- •Anthropometry: height, weight, sitting height, blood pressure, Tanner stages

Every 6–12 mo
- •In transgender males: hemoglobin/hematocrit, lipids, testosterone, 25OH vitamin D
- •In transgender females: prolactin, estradiol, 25OH vitamin D

Every 1–2 y
- •BMD using DXA
- •Bone age on X-ray of the left hand (if clinically indicated)

BMD should be monitored into adulthood (until the age of 25–30 y or until peak bone mass has been reached).
For recommendations on monitoring once pubertal induction has been completed, see Tables 14 and 15.

Adapted from Hembree *et al.* (118).

Abbreviation: DXA, dual-energy X-ray absorptiometry.

doi: 10.1210/jc.2017-01658

for 6 to 7 years before initiating sex hormones (*e.g.*, if someone reached Tanner stage 2 at age 9-10 years old). Additionally, there may be concerns about inappropriate height and potential harm to mental health (emotional and social isolation) if initiation of secondary sex characteristics must wait until the person has reached 16 years of age. However, only minimal data supporting earlier use of gender-affirming hormones in transgender adolescents currently exist (63). Clearly, long-term studies are needed to determine the optimal age of sex hormone treatment in GD/gender-incongruent adolescents.

The MHP who has followed the adolescent during GnRH analog treatment plays an essential role in assessing whether the adolescent is eligible to start sex hormone therapy and capable of consenting to this treatment (Table 5). Support of the family/environment is essential. Prior to the start of sex hormones, clinicians should discuss the implications for fertility (see recommendation 1.5). Throughout pubertal induction, an MHP and a pediatric endocrinologist (or other clinician competent in the evaluation and induction of pubertal development) should monitor the adolescent. In addition to monitoring therapy, it is also important to pay attention to general adolescent health issues, including healthy life style choices, such as not smoking, contraception, and appropriate vaccinations (*e.g.*, human papillomavirus).

For the induction of puberty, clinicians can use a similar dose scheme for hypogonadal adolescents with GD/gender incongruence as they use in other individuals with hypogonadism, carefully monitoring for desired and undesired effects (Table 8). In transgender female adolescents, transdermal 17β-estradiol may be an alternative for oral 17β-estradiol. It is increasingly used for pubertal induction in hypogonadal females. However, the absence of low-dose estrogen patches may be a problem. As a result, individuals may need to cut patches to size themselves to achieve appropriate dosing (123). In transgender male adolescents, clinicians can give testosterone injections intramuscularly or subcutaneously (124, 125).

When puberty is initiated with a gradually increasing schedule of sex steroid doses, the initial levels will not be high enough to suppress endogenous sex steroid secretion. Gonadotropin secretion and endogenous production of testosterone may resume and interfere with the effectiveness of estrogen treatment, in transgender female adolescents (126, 127). Therefore, continuation of GnRH analog treatment is advised until gonadectomy. Given that GD/gender-incongruent adolescents may opt not to have gonadectomy, long-term studies are necessary to examine the potential risks of prolonged GnRH analog treatment. Alternatively, in transgender male adolescents, GnRH analog treatment can be discontinued once an adult dose of testosterone has been reached and the individual is well virilized. If uterine bleeding occurs, a progestin can be added. However, the combined use of a GnRH analog (for ovarian suppression) and testosterone may enable phenotypic transition with a lower dose of testosterone in comparison with testosterone alone. If there is a wish or need to discontinue GnRH analog treatment in transgender female adolescents, they may be treated with an antiandrogen that directly suppresses androgen synthesis or action (see section 3.0 "Hormonal Therapy for Transgender Adults").

Values and preferences

The recommendation to initiate pubertal induction only when the individual has sufficient mental capacity (roughly age 16 years) to give informed consent for this partly irreversible treatment places a higher value on the ability of the adolescent to fully understand and oversee the partially irreversible consequences of sex hormone treatment and to give informed consent. It places a lower value on the possible negative effects of delayed puberty. We may not currently have the means to weigh adequately the potential benefits of waiting until around age 16 years to initiate sex hormones vs the potential risks/harm to BMD and the sense of social isolation from having the timing of puberty be so out of sync with peers (128).

Remarks

Before starting sex hormone treatment, effects on fertility and options for fertility preservation should be discussed. Adult height may be a concern in transgender adolescents. In a transgender female adolescent, clinicians may consider higher doses of estrogen or a more rapid tempo of dose escalation during pubertal induction. There are no established treatments yet to augment adult height in a transgender male adolescent with open epiphyses during pubertal induction. It is not uncommon for transgender adolescents to present for clinical services after having completed or nearly completed puberty. In such cases, induction of puberty with sex hormones can be done more rapidly (see Table 8). Additionally, an adult dose of testosterone in transgender male adolescents may suffice to suppress the gonadal axis without the need to use a separate agent. At the appropriate time, the multidisciplinary team should adequately prepare the adolescent for transition to adult care.

3.0 Hormonal Therapy for Transgender Adults

The two major goals of hormonal therapy are (1) to reduce endogenous sex hormone levels, and thus reduce

the secondary sex characteristics of the individual's designated gender, and (2) to replace endogenous sex hormone levels consistent with the individual's gender identity by using the principles of hormone replacement treatment of hypogonadal patients. The timing of these two goals and the age at which to begin treatment with the sex hormones of the chosen gender is codetermined in collaboration with both the person pursuing transition and the health care providers. The treatment team should include a medical provider knowledgeable in transgender hormone therapy, an MHP knowledgeable in GD/gender incongruence and the mental health concerns of transition, and a primary care provider able to provide care appropriate for transgender individuals. The physical changes induced by this sex hormone transition are usually accompanied by an improvement in mental well-being (129, 130).

3.1. We recommend that clinicians confirm the diagnostic criteria of GD/gender incongruence and the criteria for the endocrine phase of gender transition before beginning treatment. (1 |⊕⊕⊕◯)

3.2. We recommend that clinicians evaluate and address medical conditions that can be exacerbated by hormone depletion and treatment with sex hormones of the affirmed gender before beginning treatment (Table 10). (1 |⊕⊕⊕◯)

3.3. We suggest that clinicians measure hormone levels during treatment to ensure that endogenous sex steroids are suppressed and administered sex steroids are maintained in the normal physiologic range for the affirmed gender. (2 |⊕⊕◯◯)

Evidence

It is the responsibility of the treating clinician to confirm that the person fulfills criteria for treatment. The treating clinician should become familiar with the terms and criteria presented in Tables 1–5 and take a thorough history from the patient in collaboration with the other members of the treatment team. The treating clinician must ensure that the desire for transition is appropriate; the consequences, risks, and benefits of treatment are well understood; and the desire for transition persists. They also need to discuss fertility preservation options (see recommendation 1.3) (67, 68).

Transgender males

Clinical studies have demonstrated the efficacy of several different androgen preparations to induce masculinization in transgender males (Appendix A) (113, 114, 131–134). Regimens to change secondary sex characteristics follow the general principle of hormone replacement treatment of male hypogonadism (135). Clinicians can use either parenteral or transdermal preparations to achieve testosterone values in the normal male range (this is dependent on the specific assay, but is typically 320 to 1000 ng/dL) (Table 11) (136). Sustained supraphysiologic levels of testosterone increase the risk of adverse reactions (see section 4.0 "Adverse Outcome Prevention and Long-Term Care") and should be avoided.

Similar to androgen therapy in hypogonadal men, testosterone treatment in transgender males results in increased muscle mass and decreased fat mass, increased facial hair and acne, male pattern baldness in those genetically predisposed, and increased sexual desire (137).

Table 10. Medical Risks Associated With Sex Hormone Therapy

Transgender female: estrogen
Very high risk of adverse outcomes:
•Thromboembolic disease
Moderate risk of adverse outcomes:
•Macroprolactinoma
•Breast cancer
•Coronary artery disease
•Cerebrovascular disease
•Cholelithiasis
•Hypertriglyceridemia
Transgender male: testosterone
Very high risk of adverse outcomes:
•Erythrocytosis (hematocrit > 50%)
Moderate risk of adverse outcomes:
•Severe liver dysfunction (transaminases > threefold upper limit of normal)
•Coronary artery disease
•Cerebrovascular disease
•Hypertension
•Breast or uterine cancer

doi: 10.1210/jc.2017-01658

Table 11. Hormone Regimens in Transgender Persons

Transgender females[a]	
Estrogen	
Oral	
Estradiol	2.0–6.0 mg/d
Transdermal	
Estradiol transdermal patch (New patch placed every 3–5 d)	0.025–0.2 mg/d
Parenteral	
Estradiol valerate or cypionate	5–30 mg IM every 2 wk 2–10 mg IM every week
Anti-androgens	
Spironolactone	100–300 mg/d
Cyproterone acetate[b]	25–50 mg/d
GnRH agonist	3.75 mg SQ (SC) monthly 11.25 mg SQ (SC) 3-monthly
Transgender males	
Testosterone	
Parenteral testosterone	
Testosterone enanthate or cypionate	100–200 mg SQ (IM) every 2 wk or SQ (SC) 50% per week
Testosterone undecanoate[c]	1000 mg every 12 wk
Transdermal testosterone	
Testosterone gel 1.6%[d]	50–100 mg/d
Testosterone transdermal patch	2.5–7.5 mg/d

Abbreviations: IM, intramuscularly; SQ, sequentially; SC, subcutaneously.

[a]Estrogens used with or without antiandrogens or GnRH agonist.

[b]Not available in the United States.

[c]One thousand milligrams initially followed by an injection at 6 wk then at 12-wk intervals.

[d]Avoid cutaneous transfer to other individuals.

In transgender males, testosterone will result in clitoromegaly, temporary or permanent decreased fertility, deepening of the voice, cessation of menses (usually), and a significant increase in body hair, particularly on the face, chest, and abdomen. Cessation of menses may occur within a few months with testosterone treatment alone, although high doses of testosterone may be required. If uterine bleeding continues, clinicians may consider the addition of a progestational agent or endometrial ablation (138). Clinicians may also administer GnRH analogs or depot medroxyprogesterone to stop menses prior to testosterone treatment.

Transgender females

The hormone regimen for transgender females is more complex than the transgender male regimen (Appendix B). Treatment with physiologic doses of estrogen alone is insufficient to suppress testosterone levels into the normal range for females (139). Most published clinical studies report the need for adjunctive therapy to achieve testosterone levels in the female range (21, 113, 114, 132–134, 139, 140).

Multiple adjunctive medications are available, such as progestins with antiandrogen activity and GnRH agonists (141). Spironolactone works by directly blocking androgens during their interaction with the androgen receptor (114, 133, 142). It may also have estrogenic activity (143). Cyproterone acetate, a progestational compound with antiandrogenic properties (113, 132, 144), is widely used in Europe. 5α-Reductase inhibitors do not reduce testosterone levels and have adverse effects (145).

Dittrich *et al.* (141) reported that monthly doses of the GnRH agonist goserelin acetate in combination with estrogen were effective in reducing testosterone levels with a low incidence of adverse reactions in 60 transgender females. Leuprolide and transdermal estrogen were as effective as cyproterone and transdermal estrogen in a comparative retrospective study (146).

Patients can take estrogen as oral conjugated estrogens, oral 17β-estradiol, or transdermal 17β-estradiol. Among estrogen options, the increased risk of thromboembolic events associated with estrogens in general seems most concerning with ethinyl estradiol specifically (134, 140, 141), which is why we specifically suggest that it not be used in any transgender treatment plan. Data distinguishing among other estrogen options are less well established although there is some thought that oral routes of administration are more thrombogenic due to the "first pass effect" than are transdermal and parenteral routes, and that the risk of thromboembolic events is dose-dependent. Injectable estrogen and sublingual

estrogen may benefit from avoiding the first pass effect, but they can result in more rapid peaks with greater overall periodicity and thus are more difficult to monitor (147, 148). However, there are no data demonstrating that increased periodicity is harmful otherwise.

Clinicians can use serum estradiol levels to monitor oral, transdermal, and intramuscular estradiol. Blood tests cannot monitor conjugated estrogens or synthetic estrogen use. Clinicians should measure serum estradiol and serum testosterone and maintain them at the level for premenopausal females (100 to 200 pg/mL and <50 ng/dL, respectively). The transdermal preparations and injectable estradiol cypionate or valerate preparations may confer an advantage in older transgender females who may be at higher risk for thromboembolic disease (149).

Values

Our recommendation to maintain levels of gender-affirming hormones in the normal adult range places a high value on the avoidance of the long-term complications of pharmacologic doses. Those patients receiving endocrine treatment who have relative contraindications to hormones should have an in-depth discussion with their physician to balance the risks and benefits of therapy.

Remarks

Clinicians should inform all endocrine-treated individuals of all risks and benefits of gender-affirming hormones prior to initiating therapy. Clinicians should strongly encourage tobacco use cessation in transgender females to avoid increased risk of VTE and cardiovascular complications. We strongly discourage the unsupervised use of hormone therapy (150).

Not all individuals with GD/gender incongruence seek treatment as described (*e.g.*, male-to-eunuchs and individuals seeking partial transition). Tailoring current protocols to the individual may be done within the context of accepted safety guidelines using a multidisciplinary approach including mental health. No evidence-based protocols are available for these groups (151). We need prospective studies to better understand treatment options for these persons.

3.4. We suggest that endocrinologists provide education to transgender individuals undergoing treatment about the onset and time course of physical changes induced by sex hormone treatment. (2 |⊕○○○)

Evidence

Transgender males

Physical changes that are expected to occur during the first 1 to 6 months of testosterone therapy include cessation of menses, increased sexual desire, increased facial and body hair, increased oiliness of skin, increased muscle, and redistribution of fat mass. Changes that occur within the first year of testosterone therapy include deepening of the voice (152, 153), clitoromegaly, and male pattern hair loss (in some cases) (114, 144, 154, 155) (Table 12).

Transgender females

Physical changes that may occur in transgender females in the first 3 to 12 months of estrogen and antiandrogen therapy include decreased sexual desire, decreased spontaneous erections, decreased facial and body hair (usually mild), decreased oiliness of skin, increased breast tissue growth, and redistribution of fat mass (114, 139, 149, 154, 155, 161) (Table 13). Breast development is generally maximal at 2 years after initiating hormones (114, 139, 149, 155). Over a long period of time, the prostate gland and testicles will undergo atrophy.

Although the time course of breast development in transgender females has been studied (150), precise information about other changes induced by sex hormones is lacking (141). There is a great deal of variability among individuals, as evidenced during pubertal development. We all know that a major concern for transgender females is breast development. If we work with estrogens, the result will be often not what the transgender female expects.

Alternatively, there are transgender females who report an anecdotal improved breast development, mood, or sexual desire with the use of progestogens. However, there have been no well-designed studies of the role of progestogens in feminizing hormone regimens, so the question is still open.

Our knowledge concerning the natural history and effects of different cross-sex hormone therapies on breast

Table 12. Masculinizing Effects in Transgender Males

Effect	Onset	Maximum
Skin oiliness/acne	1–6 mo	1–2 y
Facial/body hair growth	6–12 mo	4–5 y
Scalp hair loss	6–12 mo	—[a]
Increased muscle mass/strength	6–12 mo	2–5 y
Fat redistribution	1–6 mo	2–5 y
Cessation of menses	1–6 mo	—[b]
Clitoral enlargement	1–6 mo	1–2 y
Vaginal atrophy	1–6 mo	1–2 y
Deepening of voice	6–12 mo	1–2 y

Estimates represent clinical observations: Toorians *et al.* (149), Asscheman *et al.* (156), Gooren *et al.* (157), Wierckx *et al.* (158).

[a] Prevention and treatment as recommended for biological men.

[b] Menorrhagia requires diagnosis and treatment by a gynecologist.

doi: 10.1210/jc.2017-01658

Table 13. Feminizing Effects in Transgender Females

Effect	Onset	Maximum
Redistribution of body fat	3–6 mo	2–3 y
Decrease in muscle mass and strength	3–6 mo	1–2 y
Softening of skin/decreased oiliness	3–6 mo	Unknown
Decreased sexual desire	1–3 mo	3–6 mo
Decreased spontaneous erections	1–3 mo	3–6 mo
Male sexual dysfunction	Variable	Variable
Breast growth	3–6 mo	2–3 y
Decreased testicular volume	3–6 mo	2–3 y
Decreased sperm production	Unknown	>3 y
Decreased terminal hair growth	6–12 mo	>3 y[a]
Scalp hair	Variable	—[b]
Voice changes	None	—[c]

Estimates represent clinical observations: Toorians *et al.* (149), Asscheman *et al.* (156), Gooren *et al.* (157).

[a]Complete removal of male sexual hair requires electrolysis or laser treatment or both.

[b]Familial scalp hair loss may occur if estrogens are stopped.

[c]Treatment by speech pathologists for voice training is most effective.

development in transgender females is extremely sparse and based on the low quality of evidence. Current evidence does not indicate that progestogens enhance breast development in transgender females, nor does evidence prove the absence of such an effect. This prevents us from drawing any firm conclusion at this moment and demonstrates the need for further research to clarify these important clinical questions (162).

Values and preferences

Transgender persons have very high expectations regarding the physical changes of hormone treatment and are aware that body changes can be enhanced by surgical procedures (*e.g.*, breast, face, and body habitus). Clear expectations for the extent and timing of sex hormone–induced changes may prevent the potential harm and expense of unnecessary procedures.

4.0 Adverse Outcome Prevention and Long-Term Care

Hormone therapy for transgender males and females confers many of the same risks associated with sex hormone replacement therapy in nontransgender persons. The risks arise from and are worsened by inadvertent or intentional use of supraphysiologic doses of sex hormones, as well as use of inadequate doses of sex hormones to maintain normal physiology (131, 139).

4.1. We suggest regular clinical evaluation for physical changes and potential adverse changes in response to sex steroid hormones and laboratory monitoring of sex steroid hormone levels every 3 months during the first year of hormone therapy for transgender males and females and then once or twice yearly. (2 |⊕⊕◯◯)

Evidence

Pretreatment screening and appropriate regular medical monitoring are recommended for both transgender males and females during the endocrine transition and periodically thereafter (26, 155). Clinicians should monitor weight and blood pressure, conduct physical exams, and assess routine health questions, such as tobacco use, symptoms of depression, and risk of adverse events such as deep vein thrombosis/pulmonary embolism and other adverse effects of sex steroids.

Transgender males

Table 14 contains a standard monitoring plan for transgender males on testosterone therapy (154, 159). Key issues include maintaining testosterone levels in the physiologic normal male range and avoiding adverse events resulting from excess testosterone therapy, particularly erythrocytosis, sleep apnea, hypertension, excessive weight gain, salt retention, lipid changes, and excessive or cystic acne (135).

Because oral 17-alkylated testosterone is not recommended, serious hepatic toxicity is not anticipated with parenteral or transdermal testosterone use (163, 164). Past concerns regarding liver toxicity with testosterone have been alleviated with subsequent reports that indicate the risk of serious liver disease is minimal (144, 165, 166).

Transgender females

Table 15 contains a standard monitoring plan for transgender females on estrogens, gonadotropin suppression, or antiandrogens (160). Key issues include avoiding supraphysiologic doses or blood levels of estrogen that may lead to increased risk for thromboembolic disease, liver dysfunction, and hypertension. Clinicians should monitor serum estradiol levels using laboratories participating in external quality control, as measurements of estradiol in blood can be very challenging (167).

VTE may be a serious complication. A study reported a 20-fold increase in venous thromboembolic disease in a large cohort of Dutch transgender subjects (161). This increase may have been associated with the use of the synthetic estrogen, ethinyl estradiol (149). The incidence decreased when clinicians stopped administering ethinyl estradiol (161). Thus, the use of synthetic estrogens and conjugated estrogens is undesirable because of the inability to regulate doses by measuring serum levels and the risk of thromboembolic disease. In a German gender clinic, deep vein thrombosis occurred in 1 of 60 of transgender females treated with a GnRH analog and oral

Table 14. Monitoring of Transgender Persons on Gender-Affirming Hormone Therapy: Transgender Male

1. Evaluate patient every 3 mo in the first year and then one to two times per year to monitor for appropriate signs of virilization and for development of adverse reactions.
2. Measure serum testosterone every 3 mo until levels are in the normal physiologic male range:[a]
   a. For testosterone enanthate/cypionate injections, the testosterone level should be measured midway between injections. The target level is 400–700 ng/dL to 400 ng/dL. Alternatively, measure peak and trough levels to ensure levels remain in the normal male range.
   b. For parenteral testosterone undecanoate, testosterone should be measured just before the following injection. If the level is <400 ng/dL, adjust dosing interval.
   c. For transdermal testosterone, the testosterone level can be measured no sooner than after 1 wk of daily application (at least 2 h after application).
3. Measure hematocrit or hemoglobin at baseline and every 3 mo for the first year and then one to two times a year. Monitor weight, blood pressure, and lipids at regular intervals.
4. Screening for osteoporosis should be conducted in those who stop testosterone treatment, are not compliant with hormone therapy, or who develop risks for bone loss.
5. If cervical tissue is present, monitoring as recommended by the American College of Obstetricians and Gynecologists.
6. Ovariectomy can be considered after completion of hormone transition.
7. Conduct sub- and periareolar annual breast examinations if mastectomy performed. If mastectomy is not performed, then consider mammograms as recommended by the American Cancer Society.

[a] Adapted from Lapauw *et al.* (154) and Ott *et al.* (159).

estradiol (141). The patient who developed a deep vein thrombosis was found to have a homozygous C677 T mutation in the methylenetetrahydrofolate reductase gene. In an Austrian gender clinic, administering gender-affirming hormones to 162 transgender females and 89 transgender males was not associated with VTE, despite an 8.0% and 5.6% incidence of thrombophilia (159). A more recent multinational study reported only 10 cases of VTE from a cohort of 1073 subjects (168). Thrombophilia screening of transgender persons initiating hormone treatment should be restricted to those with a personal or family history of VTE (159). Monitoring D-dimer levels during treatment is not recommended (169).

4.2. We suggest periodically monitoring prolactin levels in transgender females treated with estrogens. (2 l⊕⊕◯◯)

Evidence

Estrogen therapy can increase the growth of pituitary lactrotroph cells. There have been several reports of prolactinomas occurring after long-term, high-dose estrogen therapy (170–173). Up to 20% of transgender females treated with estrogens may have elevations in prolactin levels associated with enlargement of the pituitary gland (156). In most cases, the serum prolactin levels will return to the normal range with a reduction or discontinuation of the estrogen therapy or discontinuation of cyproterone acetate (157, 174, 175).

The onset and time course of hyperprolactinemia during estrogen treatment are not known. Clinicians should measure prolactin levels at baseline and then at least annually during the transition period and every 2 years thereafter. Given that only a few case studies reported prolactinomas, and prolactinomas were not reported in large cohorts of estrogen-treated persons, the risk is likely to be very low. Because the major presenting findings of microprolactinomas (hypogonadism and sometimes gynecomastia) are not apparent in transgender females, clinicians may perform radiologic examinations of the pituitary in those patients whose prolactin levels persistently increase despite stable or reduced estrogen levels. Some transgender individuals receive psychotropic medications that can increase prolactin levels (174).

Table 15. Monitoring of Transgender Persons on Gender-Affirming Hormone Therapy: Transgender Female

1. Evaluate patient every 3 mo in the first year and then one to two times per year to monitor for appropriate signs of feminization and for development of adverse reactions.
2. Measure serum testosterone and estradiol every 3 mo.
   a. Serum testosterone levels should be <50 ng/dL.
   b. Serum estradiol should not exceed the peak physiologic range: 100–200 pg/mL.
3. For individuals on spironolactone, serum electrolytes, particularly potassium, should be monitored every 3 mo in the first year and annually thereafter.
4. Routine cancer screening is recommended, as in nontransgender individuals (all tissues present).
5. Consider BMD testing at baseline (160). In individuals at low risk, screening for osteoporosis should be conducted at age 60 years or in those who are not compliant with hormone therapy.

This table presents strong recommendations and does not include lower level recommendations.

doi: 10.1210/jc.2017-01658

4.3. We suggest that clinicians evaluate transgender persons treated with hormones for cardiovascular risk factors using fasting lipid profiles, diabetes screening, and/or other diagnostic tools. (2 ⊕⊕◯◯)

Evidence

Transgender males

Administering testosterone to transgender males results in a more atherogenic lipid profile with lowered high-density lipoprotein cholesterol and higher triglyceride and low-density lipoprotein cholesterol values (176–179). Studies of the effect of testosterone on insulin sensitivity have mixed results (178, 180). A randomized, open-label uncontrolled safety study of transgender males treated with testosterone undecanoate demonstrated no insulin resistance after 1 year (181, 182). Numerous studies have demonstrated the effects of sex hormone treatment on the cardiovascular system (160, 179, 183, 184). Long-term studies from The Netherlands found no increased risk for cardiovascular mortality (161). Likewise, a meta-analysis of 19 randomized trials in nontransgender males on testosterone replacement showed no increased incidence of cardiovascular events (185). A systematic review of the literature found that data were insufficient (due to very low–quality evidence) to allow a meaningful assessment of patient-important outcomes, such as death, stroke, myocardial infarction, or VTE in transgender males (176). Future research is needed to ascertain the potential harm of hormonal therapies (176). Clinicians should manage cardiovascular risk factors as they emerge according to established guidelines (186).

Transgender females

A prospective study of transgender females found favorable changes in lipid parameters with increased high-density lipoprotein and decreased low-density lipoprotein concentrations (178). However, increased weight, blood pressure, and markers of insulin resistance attenuated these favorable lipid changes. In a meta-analysis, only serum triglycerides were higher at ≥24 months without changes in other parameters (187). The largest cohort of transgender females (mean age 41 years, followed for a mean of 10 years) showed no increase in cardiovascular mortality despite a 32% rate of tobacco use (161).

Thus, there is limited evidence to determine whether estrogen is protective or detrimental on lipid and glucose metabolism in transgender females (176). With aging, there is usually an increase of body weight. Therefore, as with nontransgender individuals, clinicians should monitor and manage glucose and lipid metabolism and blood pressure regularly according to established guidelines (186).

4.4. We recommend that clinicians obtain BMD measurements when risk factors for osteoporosis exist, specifically in those who stop sex hormone therapy after gonadectomy. (1 ⊕⊕◯◯)

Evidence

Transgender males

Baseline bone mineral measurements in transgender males are generally in the expected range for their pretreatment gender (188). However, adequate dosing of testosterone is important to maintain bone mass in transgender males (189, 190). In one study (190), serum LH levels were inversely related to BMD, suggesting that low levels of sex hormones were associated with bone loss. Thus, LH levels in the normal range may serve as an indicator of the adequacy of sex steroid administration to preserve bone mass. The protective effect of testosterone may be mediated by peripheral conversion to estradiol, both systemically and locally in the bone.

Transgender females

A baseline study of BMD reported T scores less than −2.5 in 16% of transgender females (191). In aging males, studies suggest that serum estradiol more positively correlates with BMD than does testosterone (192, 193) and is more important for peak bone mass (194). Estrogen preserves BMD in transgender females who continue on estrogen and antiandrogen therapies (188, 190, 191, 195, 196).

Fracture data in transgender males and females are not available. Transgender persons who have undergone gonadectomy may choose not to continue consistent sex steroid treatment after hormonal and surgical sex reassignment, thereby becoming at risk for bone loss. There have been no studies to determine whether clinicians should use the sex assigned at birth or affirmed gender for assessing osteoporosis (*e.g.*, when using the FRAX tool). Although some researchers use the sex assigned at birth (with the assumption that bone mass has usually peaked for transgender people who initiate hormones in early adulthood), this should be assessed on a case-by-case basis until there are more data available. This assumption will be further complicated by the increasing prevalence of transgender people who undergo hormonal transition at a pubertal age or soon after puberty. Sex for comparison within risk assessment tools may be based on the age at which hormones were initiated and the length of exposure to hormones. In some cases, it may be

reasonable to assess risk using both the male and female calculators and using an intermediate value. Because all subjects underwent normal pubertal development, with known effects on bone size, reference values for birth sex were used for all participants (154).

4.5. We suggest that transgender females with no known increased risk of breast cancer follow breast-screening guidelines recommended for those designated female at birth. (2 ⊕⊕◯◯)

4.6. We suggest that transgender females treated with estrogens follow individualized screening according to personal risk for prostatic disease and prostate cancer. (2 ⊕◯◯◯)

Evidence

Studies have reported a few cases of breast cancer in transgender females (197–200). A Dutch study of 1800 transgender females followed for a mean of 15 years (range of 1 30 years) found one case of breast cancer. The Women's Health Initiative study reported that females taking conjugated equine estrogen without progesterone for 7 years did not have an increased risk of breast cancer as compared with females taking placebo (137).

In transgender males, a large retrospective study conducted at the U.S. Veterans Affairs medical health system identified seven breast cancers (194). The authors reported that this was not above the expected rate of breast cancers in cisgender females in this cohort. Furthermore, they did report one breast cancer that developed in a transgender male patient after mastectomy, supporting the fact that breast cancer can occur even after mastectomy. Indeed, there have been case reports of breast cancer developing in subareolar tissue in transgender males, which occurred after mastectomy (201, 202).

Women with primary hypogonadism (Turner syndrome) treated with estrogen replacement exhibited a significantly decreased incidence of breast cancer as compared with national standardized incidence ratios (203, 204). These studies suggest that estrogen therapy does not increase the risk of breast cancer in the short term (<20 to 30 years). We need long-term studies to determine the actual risk, as well as the role of screening mammograms. Regular examinations and gynecologic advice should determine monitoring for breast cancer.

Prostate cancer is very rare before the age of 40, especially with androgen deprivation therapy (205). Childhood or pubertal castration results in regression of the prostate and adult castration reverses benign prostate hypertrophy (206). Although van Kesteren *et al.* (207) reported that estrogen therapy does not induce hypertrophy or premalignant changes in the prostates of transgender females, studies have reported cases of benign prostatic hyperplasia in transgender females treated with estrogens for 20 to 25 years (208, 209). Studies have also reported a few cases of prostate carcinoma in transgender females (210–214).

Transgender females may feel uncomfortable scheduling regular prostate examinations. Gynecologists are not trained to screen for prostate cancer or to monitor prostate growth. Thus, it may be reasonable for transgender females who transitioned after age 20 years to have annual screening digital rectal examinations after age 50 years and prostate-specific antigen tests consistent with U.S. Preventive Services Task Force Guidelines (215).

4.7. We advise that clinicians determine the medical necessity of including a total hysterectomy and oophorectomy as part of gender-affirming surgery. (Ungraded Good Practice Statement)

Evidence

Although aromatization of testosterone to estradiol in transgender males has been suggested as a risk factor for endometrial cancer (216), no cases have been reported. When transgender males undergo hysterectomy, the uterus is small and there is endometrial atrophy (217, 218). Studies have reported cases of ovarian cancer (219, 220). Although there is limited evidence for increased risk of reproductive tract cancers in transgender males, health care providers should determine the medical necessity of a laparoscopic total hysterectomy as part of a gender-affirming surgery to prevent reproductive tract cancer (221).

Values

Given the discomfort that transgender males experience accessing gynecologic care, our recommendation for the medical necessity of total hysterectomy and oophorectomy places a high value on eliminating the risks of female reproductive tract disease and cancer and a lower value on avoiding the risks of these surgical procedures (related to the surgery and to the potential undesirable health consequences of oophorectomy) and their associated costs.

Remarks

The sexual orientation and type of sexual practices will determine the need and types of gynecologic care required following transition. Additionally, in certain countries, the approval required to change the sex in a birth certificate for transgender males may be dependent on having a complete hysterectomy. Clinicians should help patients research nonmedical administrative criteria and

doi: 10.1210/jc.2017-01658

provide counseling. If individuals decide not to undergo hysterectomy, screening for cervical cancer is the same as all other females.

5.0 Surgery for Sex Reassignment and Gender Confirmation

For many transgender adults, genital gender-affirming surgery may be the necessary step toward achieving their ultimate goal of living successfully in their desired gender role. The type of surgery falls into two main categories: (1) those that directly affect fertility and (2) those that do not. Those that change fertility (previously called sex reassignment surgery) include genital surgery to remove the penis and gonads in the male and removal of the uterus and gonads in the female. The surgeries that effect fertility are often governed by the legal system of the state or country in which they are performed. Other gender-conforming surgeries that do not directly affect fertility are not so tightly governed.

Gender-affirming surgical techniques have improved markedly during the past 10 years. Reconstructive genital surgery that preserves neurologic sensation is now the standard. The satisfaction rate with surgical reassignment of sex is now very high (187). Additionally, the mental health of the individual seems to be improved by participating in a treatment program that defines a pathway of gender-affirming treatment that includes hormones and surgery (130, 144) (Table 16).

Surgery that affects fertility is irreversible. The World Professional Association for Transgender Health Standards of Care (222) emphasizes that the "threshold of 18 should not be seen as an indication in itself for active intervention." If the social transition has not been satisfactory, if the person is not satisfied with or is ambivalent about the effects of sex hormone treatment, or if the person is ambivalent about surgery then the individual should not be referred for surgery (223, 224).

Gender-affirming genital surgeries for transgender females that affect fertility include gonadectomy, penectomy, and creation of a neovagina (225, 226). Surgeons often invert the skin of the penis to form the wall of the vagina, and several literatures reviews have reported on outcomes (227). Sometimes there is inadequate tissue to form a full neovagina, so clinicians have revisited using intestine and found it to be successful (87, 228, 229). Some newer vaginoplasty techniques may involve autologuous oral epithelial cells (230, 231).

The scrotum becomes the labia majora. Surgeons use reconstructive surgery to fashion the clitoris and its hood, preserving the neurovascular bundle at the tip of the penis as the neurosensory supply to the clitoris. Some surgeons are also creating a sensate pedicled-spot adding a G spot to the neovagina to increase sensation (232). Most recently, plastic surgeons have developed techniques to fashion labia minora. To further complete the feminization, uterine transplants have been proposed and even attempted (233).

Neovaginal prolapse, rectovaginal fistula, delayed healing, vaginal stenosis, and other complications do sometimes occur (234, 235). Clinicians should strongly remind the transgender person to use their dilators to maintain the depth and width of the vagina throughout the postoperative period. Genital sexual responsivity and other aspects of sexual function are usually preserved following genital gender-affirming surgery (236, 237).

Ancillary surgeries for more feminine or masculine appearance are not within the scope of this guideline. Voice therapy by a speech language pathologist is available to transform speech patterns to the affirmed gender (148). Spontaneous voice deepening occurs during testosterone treatment of transgender males (152, 238). No studies have compared the effectiveness of speech therapy, laryngeal surgery, or combined treatment.

Breast surgery is a good example of gender-confirming surgery that does not affect fertility. In all females, breast size exhibits a very broad spectrum. For transgender females to make the best informed decision, clinicians should delay breast augmentation surgery until the patient has completed at least 2 years of estrogen therapy, because the breasts continue to grow during that time (141, 155).

Another major procedure is the removal of facial and masculine-appearing body hair using either electrolysis or

Table 16. Criteria for Gender-Affirming Surgery, Which Affects Fertility

1. Persistent, well-documented gender dysphoria
2. Legal age of majority in the given country
3. Having continuously and responsibly used gender-affirming hormones for 12 mo (if there is no medical contraindication to receiving such therapy)
4. Successful continuous full-time living in the new gender role for 12 mo
5. If significant medical or mental health concerns are present, they must be well controlled
6. Demonstrable knowledge of all practical aspects of surgery (*e.g.*, cost, required lengths of hospitalizations, likely complications, postsurgical rehabilitation)

laser treatments. Other feminizing surgeries, such as that to feminize the face, are now becoming more popular (239–241).

In transgender males, clinicians usually delay gender-affirming genital surgeries until after a few years of androgen therapy. Those surgeries that affect fertility in this group include oophorectomy, vaginectomy, and complete hysterectomy. Surgeons can safely perform them vaginally with laparoscopy. These are sometimes done in conjunction with the creation of a neopenis. The cosmetic appearance of a neopenis is now very good, but the surgery is multistage and very expensive (242, 243). Radial forearm flap seems to be the most satisfactory procedure (228, 244). Other flaps also exist (245). Surgeons can make neopenile erections possible by reinervation of the flap and subsequent contraction of the muscle, leading to stiffening of the neopenis (246, 247), but results are inconsistent (248). Surgeons can also stiffen the penis by imbedding some mechanical device (*e.g.*, a rod or some inflatable apparatus) (249, 250). Because of these limitations, the creation of a neopenis has often been less than satisfactory. Recently, penis transplants are being proposed (233).

In fact, most transgender males do not have any external genital surgery because of the lack of access, high cost, and significant potential complications. Some choose a metaoidioplasty that brings forward the clitoris, thereby allowing them to void in a standing position without wetting themselves (251, 252). Surgeons can create the scrotum from the labia majora with good cosmetic effect and can implant testicular prostheses (253).

The most important masculinizing surgery for the transgender male is mastectomy, and it does not affect fertility. Breast size only partially regresses with androgen therapy (155). In adults, discussions about mastectomy usually take place after androgen therapy has started. Because some transgender male adolescents present after significant breast development has occurred, they may also consider mastectomy 2 years after they begin androgen therapy and before age 18 years. Clinicians should individualize treatment based on the physical and mental health status of the individual. There are now newer approaches to mastectomy with better outcomes (254, 255). These often involve chest contouring (256). Mastectomy is often necessary for living comfortably in the new gender (256).

5.1. We recommend that a patient pursue genital gender-affirming surgery only after the MHP and the clinician responsible for endocrine transition therapy both agree that surgery is medically necessary and would benefit the patient's overall health and/or well-being. (1 ⊕⊕◯◯)

5.2. We advise that clinicians approve genital gender-affirming surgery only after completion of at least 1 year of consistent and compliant hormone treatment, unless hormone therapy is not desired or medically contraindicated. (Ungraded Good Practice Statement)

5.3. We advise that the clinician responsible for endocrine treatment and the primary care provider ensure appropriate medical clearance of transgender individuals for genital gender-affirming surgery and collaborate with the surgeon regarding hormone use during and after surgery. (Ungraded Good Practice Statement)

5.4. We recommend that clinicians refer hormone-treated transgender individuals for genital surgery when: (1) the individual has had a satisfactory social role change, (2) the individual is satisfied about the hormonal effects, and (3) the individual desires definitive surgical changes. (1 ⊕◯◯◯)

5.5. We suggest that clinicians delay gender-affirming genital surgery involving gonadectomy and/or hysterectomy until the patient is at least 18 years old or legal age of majority in his or her country. (2 ⊕⊕◯◯).

5.6. We suggest that clinicians determine the timing of breast surgery for transgender males based upon the physical and mental health status of the individual. There is insufficient evidence to recommend a specific age requirement. (2 ⊕◯◯◯)

Evidence

Owing to the lack of controlled studies, incomplete follow-up, and lack of valid assessment measures, evaluating various surgical approaches and techniques is difficult. However, one systematic review including a large numbers of studies reported satisfactory cosmetic and functional results for vaginoplasty/neovagina construction (257). For transgender males, the outcomes are less certain. However, the problems are now better understood (258). Several postoperative studies report significant long-term psychological and psychiatric pathology (259–261). One study showed satisfaction with breasts, genitals, and femininity increased significantly and showed the importance of surgical treatment as a key therapeutic option for transgender females (262). Another analysis demonstrated that, despite the young average age at death following surgery and the relatively larger number of individuals with somatic morbidity, the study does not allow for determination of

doi: 10.1210/jc.2017-01658

causal relationships between, for example, specific types of hormonal or surgical treatment received and somatic morbidity and mortality (263). Reversal surgery in regretful male-to-female transsexuals after sexual reassignment surgery represents a complex, multistage procedure with satisfactory outcomes. Further insight into the characteristics of persons who regret their decision postoperatively would facilitate better future selection of applicants eligible for sexual reassignment surgery. We need more studies with appropriate controls that examine long-term quality of life, psychosocial outcomes, and psychiatric outcomes to determine the long-term benefits of surgical treatment.

When a transgender individual decides to have gender-affirming surgery, both the hormone prescribing clinician and the MHP must certify that the patient satisfies criteria for gender-affirming surgery (Table 16).

There is some concern that estrogen therapy may cause an increased risk for venous thrombosis during or following surgery (176). For this reason, the surgeon and the hormone-prescribing clinician should collaborate in making a decision about the use of hormones before and following surgery. One study suggests that preoperative factors (such as compliance) are less important for patient satisfaction than are the physical postoperative results (56). However, other studies and clinical experience dictate that individuals who do not follow medical instructions and do not work with their physicians toward a common goal do not achieve treatment goals (264) and experience higher rates of postoperative infections and other complications (265, 266). It is also important that the person requesting surgery feels comfortable with the anatomical changes that have occurred during hormone therapy. Dissatisfaction with social and physical outcomes during the hormone transition may be a contraindication to surgery (223).

An endocrinologist or experienced medical provider should monitor transgender individuals after surgery. Those who undergo gonadectomy will require hormone replacement therapy, surveillance, or both to prevent adverse effects of chronic hormone deficiency.

Financial Disclosures of the Task Force*

Wylie C. Hembree (chair)—financial or business/organizational interests: none declared, significant financial interest or leadership position: none declared. **Peggy T. Cohen-Kettenis**—financial or business/organizational interests: none declared, significant financial interest or leadership position: none declared. **Louis Gooren**—financial or business/organizational interests: none declared, significant financial interest or leadership position: none declared. **Sabine E. Hannema**—financial or business/organizational interests: none declared, significant financial interest or leadership position: Ferring Pharmaceuticals Inc. (lecture/conference), Pfizer (lecture). **Walter J. Meyer**—financial or business/organizational interests: none declared, significant financial interest or leadership position: none declared. **M. Hassan Murad****—financial or business/organizational interests: Mayo Clinic, Evidence-based Practice Center, significant financial interest or leadership position: none declared. **Stephen M. Rosenthal**—financial or business/organizational interests: AbbVie (consultant), National Institutes of Health (grantee), significant financial interest or leadership position: Pediatric Endocrine Society (immediate past president). **Joshua D. Safer, FACP**—financial or business/organizational interests: none declared, significant financial interest or leadership position: none declared. **Vin Tangpricha**—financial or business/organizational interests: Cystic Fibrosis Foundation (grantee), National Institutes of Health (grantee), significant financial interest or leadership position, Elsevier *Journal of Clinical and Translational Endocrinology* (editor). **Guy G. T'Sjoen**—financial or business/organizational interests: none declared, significant financial interest or leadership position: none declared.* Financial, business, and organizational disclosures of the task force cover the year prior to publication. Disclosures prior to this time period are archived.**Evidence-based reviews for this guideline were prepared under contract with the Endocrine Society.

Acknowledgments

Correspondence and Reprint Requests: The Endocrine Society, 2055 L Street NW, Suite 600, Washington, DC 20036. E-mail: publications@endocrine.org; Phone: 202971-3636.

Disclosure Summary: See Financial Disclosures.

Disclaimer: The Endocrine Society's clinical practice guidelines are developed to be of assistance to endocrinologists by providing guidance and recommendations for particular areas of practice. The guidelines should not be considered inclusive of all proper approaches or methods, or exclusive of others. The guidelines cannot guarantee any specific outcome, nor do they establish a standard of care. The guidelines are not intended to dictate the treatment of a particular patient. Treatment decisions must be made based on the independent judgement of healthcare providers and each patient's individual circumstances.

The Endocrine Society makes no warranty, express or implied, regarding the guidelines and specifically excludes any warranties of merchantability and fitness for a particular use or purpose. The Society shall not be liable for direct, indirect,

special, incidental, or consequential damages related to the use of the information contained herein.

References

1. Atkins D, Best D, Briss PA, Eccles M, Falck-Ytter Y, Flottorp S, Guyatt GH, Harbour RT, Haugh MC, Henry D, Hill S, Jaeschke R, Leng G, Liberati A, Magrini N, Mason J, Middleton P, Mrukowicz J, O'Connell D, Oxman AD, Phillips B, Schünemann HJ, Edejer T, Varonen H, Vist GE, Williams JW, Jr, Zaza S; GRADE Working Group. Grading quality of evidence and strength of recommendations. *BMJ*. 2004;**328**(7454):1490.
2. Swiglo BA, Murad MH, Schünemann HJ, Kunz R, Vigersky RA, Guyatt GH, Montori VM. A case for clarity, consistency, and helpfulness: state-of-the-art clinical practice guidelines in endocrinology using the grading of recommendations, assessment, development, and evaluation system. *J Clin Endocrinol Metab*. 2008;**93**(3):666–673.
3. Bullough VL. Transsexualism in history. *Arch Sex Behav*. 1975; **4**(5):561–571.
4. Benjamin H. The transsexual phenomenon. *Trans N Y Acad Sci*. 1967;**29**(4):428–430.
5. Meyerowitz J. *How Sex Changed: A History of Transsexuality in the United States*. Cambridge, MA: Harvard University Press; 2002.
6. Hirschfeld M. *Was muss das Volk vom Dritten Geschlecht wissen*. Verlag Max Spohr, Leipzig; 1901.
7. Fisk NM. Editorial: Gender dysphoria syndrome—the conceptualization that liberalizes indications for total gender reorientation and implies a broadly based multi-dimensional rehabilitative regimen. *West J Med*. 1974;**120**(5):386–391.
8. Diamond L. Transgender experience and identity. In: Schwartz SJ, Luyckx K, Vignoles VL, eds. *Handbook of Identity Theory and Research*. New York, NY: Springer; 2011:629–647.
9. Queen C, Schimel L, eds. *PoMoSexuals: Challenging Assumptions About Gender and Sexuality*. San Francisco, CA: Cleis Press; 1997.
10. Case LK, Ramachandran VS. Alternating gender incongruity: a new neuropsychiatric syndrome providing insight into the dynamic plasticity of brain-sex. *Med Hypotheses*. 2012;**78**(5): 626–631.
11. Johnson TW, Wassersug RJ. Gender identity disorder outside the binary: when gender identity disorder-not otherwise specified is not good enough. *Arch Sex Behav*. 2010;**39**(3):597–598.
12. Wibowo E, Wassersug R, Warkentin K, Walker L, Robinson J, Brotto L, Johnson T. Impact of androgen deprivation therapy on sexual function: a response. *Asian J Androl*. 2012;**14**(5):793–794.
13. Pasquesoone V. 7 countries giving transgender people fundamental rights the U.S. still won't. 2014. Available at: https://mic.com/articles/87149/7-countries-giving-transgender-people-fundamental-rights-the-u-s-still-won-t. Accessed 26 August 2016.
14. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 5th ed. Arlington, VA: American Psychiatric Association Publishing.
15. Drescher J, Cohen-Kettenis P, Winter S. Minding the body: situating gender identity diagnoses in the ICD-11. *Int Rev Psychiatry*. 2012;**24**(6):568–577.
16. World Professional Association for Transgender Health. Standards of care for the health of transsexual, transgender, and gender nonconforming people. Available at: http://www.wpath.org/site_page.cfm?pk_association_webpage_menu=1351&pk_association_webpage=3926. Accessed 1 September 2017.
17. Kreukels BP, Haraldsen IR, De Cuypere G, Richter-Appelt H, Gijs L, Cohen-Kettenis PT. A European network for the investigation of gender incongruence: the ENIGI initiative. *Eur Psychiatry*. 2012;**27**(6):445–450.
18. Dekker MJ, Wierckx K, Van Caenegem E, Klaver M, Kreukels BP, Elaut E, Fisher AD, van Trotsenburg MA, Schreiner T, den Heijer M, T'Sjoen G. A European network for the investigation of gender incongruence: endocrine part. *J Sex Med*. 2016;**13**(6):994–999.
19. Ruble DN, Martin CL, Berenbaum SA. Gender development. In: Damon WL, Lerner RM, Eisenberg N, eds. *Handbook of Child Psychology: Social, Emotional, and Personality Development*. **Vol. 3**. 6th ed. New York, NY: Wiley; 2006;858–931.
20. Steensma TD, Kreukels BP, de Vries AL, Cohen-Kettenis PT. Gender identity development in adolescence. *Horm Behav*. 2013; **64**(2):288–297.
21. Rosenthal SM. Approach to the patient: transgender youth: endocrine considerations. *J Clin Endocrinol Metab*. 2014;**99**(12): 4379–4389.
22. Saraswat A, Weinand JD, Safer JD. Evidence supporting the biologic nature of gender identity. *Endocr Pract*. 2015;**21**(2): 199–204.
23. Gooren L. The biology of human psychosexual differentiation. *Horm Behav*. 2006;**50**(4):589–601.
24. Berenbaum SA, Meyer-Bahlburg HF. Gender development and sexuality in disorders of sex development. *Horm Metab Res*. 2015; **47**(5):361–366.
25. Dessens AB, Slijper FME, Drop SLS. Gender dysphoria and gender change in chromosomal females with congenital adrenal hyperplasia. *Arch Sex Behav*. 2005;**34**(4):389–397.
26. Meyer-Bahlburg HFL, Dolezal C, Baker SW, Ehrhardt AA, New MI. Gender development in women with congenital adrenal hyperplasia as a function of disorder severity. *Arch Sex Behav*. 2006; **35**(6):667–684.
27. Frisén L, Nordenström A, Falhammar H, Filipsson H, Holmdahl G, Janson PO, Thorén M, Hagenfeldt K, Möller A, Nordenskjöld A. Gender role behavior, sexuality, and psychosocial adaptation in women with congenital adrenal hyperplasia due to CYP21A2 deficiency. *J Clin Endocrinol Metab*. 2009;**94**(9):3432–3439.
28. Meyer-Bahlburg HFL, Dolezal C, Baker SW, Carlson AD, Obeid JS, New MI. Prenatal androgenization affects gender-related behavior but not gender identity in 5–12-year-old girls with congenital adrenal hyperplasia. *Arch Sex Behav*. 2004;**33**(2):97–104.
29. Cohen-Kettenis PT. Gender change in 46,XY persons with 5α-reductase-2 deficiency and 17β-hydroxysteroid dehydrogenase-3 deficiency. *Arch Sex Behav*. 2005;**34**(4):399–410.
30. Reiner WG, Gearhart JP. Discordant sexual identity in some genetic males with cloacal exstrophy assigned to female sex at birth. *N Engl J Med*. 2004;**350**(4):333–341.
31. Meyer-Bahlburg HFL. Gender identity outcome in female-raised 46,XY persons with penile agenesis, cloacal exstrophy of the bladder, or penile ablation. *Arch Sex Behav*. 2005;**34**(4):423–438.
32. Coolidge FL, Thede LL, Young SE. The heritability of gender identity disorder in a child and adolescent twin sample. *Behav Genet*. 2002;**32**(4):251–257.
33. Heylens G, De Cuypere G, Zucker KJ, Schelfaut C, Elaut E, Vanden Bossche H, De Baere E, T'Sjoen G. Gender identity disorder in twins: a review of the case report literature. *J Sex Med*. 2012;**9**(3):751–757.
34. Fernández R, Esteva I, Gómez-Gil E, Rumbo T, Almaraz MC, Roda E, Haro-Mora J-J, Guillamón A, Pásaro E. Association study of ERβ, AR, and CYP19A1 genes and MtF transsexualism. *J Sex Med*. 2014;**11**(12):2986–2994.
35. Henningsson S, Westberg L, Nilsson S, Lundström B, Ekselius L, Bodlund O, Lindström E, Hellstrand M, Rosmond R, Eriksson E, Landén M. Sex steroid-related genes and male-to-female transsexualism. *Psychoneuroendocrinology*. 2005;**30**(7):657–664.
36. Hare L, Bernard P, Sánchez FJ, Baird PN, Vilain E, Kennedy T, Harley VR. Androgen receptor repeat length polymorphism associated with male-to-female transsexualism. *Biol Psychiatry*. 2009;**65**(1):93–96.
37. Lombardo F, Toselli L, Grassetti D, Paoli D, Masciandaro P, Valentini F, Lenzi A, Gandini L. Hormone and genetic study in

male to female transsexual patients. *J Endocrinol Invest*. 2013; **36**(8):550–557.
38. Ujike H, Otani K, Nakatsuka M, Ishii K, Sasaki A, Oishi T, Sato T, Okahisa Y, Matsumoto Y, Namba Y, Kimata Y, Kuroda S. Association study of gender identity disorder and sex hormone-related genes. *Prog Neuropsychopharmacol Biol Psychiatry*. 2009;**33**(7):1241–1244.
39. Kreukels BP, Guillamon A. Neuroimaging studies in people with gender incongruence. *Int Rev Psychiatry*. 2016;**28**(1): 120–128.
40. Steensma TD, Biemond R, de Boer F, Cohen-Kettenis PT. Desisting and persisting gender dysphoria after childhood: a qualitative follow-up study. *Clin Child Psychol Psychiatry*. 2011;**16**(4):499–516.
41. Wallien MSC, Cohen-Kettenis PT. Psychosexual outcome of gender-dysphoric children. *J Am Acad Child Adolesc Psychiatry*. 2008;**47**(12):1413–1423.
42. Steensma TD, McGuire JK, Kreukels BPC, Beekman AJ, Cohen-Kettenis PT. Factors associated with desistence and persistence of childhood gender dysphoria: a quantitative follow-up study. *J Am Acad Child Adolesc Psychiatry*. 2013;**52**(6):582–590.
43. Cohen-Kettenis PT, Owen A, Kaijser VG, Bradley SJ, Zucker KJ. Demographic characteristics, social competence, and behavior problems in children with gender identity disorder: a cross-national, cross-clinic comparative analysis. *J Abnorm Child Psychol*. 2003;**31**(1):41–53.
44. Dhejne C, Van Vlerken R, Heylens G, Arcelus J. Mental health and gender dysphoria: a review of the literature. *Int Rev Psychiatry*. 2016;**28**(1):44–57.
45. Pasterski V, Gilligan L, Curtis R. Traits of autism spectrum disorders in adults with gender dysphoria. *Arch Sex Behav*. 2014; **43**(2):387–393.
46. Spack NP, Edwards-Leeper L, Feldman HA, Leibowitz S, Mandel F, Diamond DA, Vance SR. Children and adolescents with gender identity disorder referred to a pediatric medical center. *Pediatrics*. 2012;**129**(3):418–425.
47. Terada S, Matsumoto Y, Sato T, Okabe N, Kishimoto Y, Uchitomi Y. Factors predicting psychiatric co-morbidity in gender-dysphoric adults. *Psychiatry Res*. 2012;**200**(2-3):469–474.
48. VanderLaan DP, Leef JH, Wood H, Hughes SK, Zucker KJ. Autism spectrum disorder risk factors and autistic traits in gender dysphoric children. *J Autism Dev Disord*. 2015;**45**(6):1742–1750.
49. de Vries ALC, Doreleijers TAH, Steensma TD, Cohen-Kettenis PT. Psychiatric comorbidity in gender dysphoric adolescents. *J Child Psychol Psychiatry*. 2011;**52**(11):1195–1202.
50. de Vries ALC, Noens ILJ, Cohen-Kettenis PT, van Berckelaer-Onnes IA, Doreleijers TA. Autism spectrum disorders in gender dysphoric children and adolescents. *J Autism Dev Disord*. 2010; **40**(8):930–936.
51. Wallien MSC, Swaab H, Cohen-Kettenis PT. Psychiatric comorbidity among children with gender identity disorder. *J Am Acad Child Adolesc Psychiatry*. 2007;**46**(10):1307–1314.
52. Kuiper AJ, Cohen-Kettenis PT. Gender role reversal among postoperative transsexuals. Available at: https://www.atria.nl/ezines/web/IJT/97-03/numbers/symposion/ijtc0502.htm. Accessed 26 August 2016.
53. Landén M, Wålinder J, Hambert G, Lundström B. Factors predictive of regret in sex reassignment. *Acta Psychiatr Scand*. 1998; **97**(4):284–289.
54. Olsson S-E, Möller A. Regret after sex reassignment surgery in a male-to-female transsexual: a long-term follow-up. *Arch Sex Behav*. 2006;**35**(4):501–506.
55. Pfäfflin F, Junge A, eds. *Geschlechtsumwandlung: Abhandlungen zur Transsexualität*. Stuttgart, Germany: Schattauer; 1992.
56. Lawrence AA. Factors associated with satisfaction or regret following male-to-female sex reassignment surgery. *Arch Sex Behav*. 2003;**32**(4):299–315.
57. Cohen-Kettenis PT, Pfäfflin F. *Transgenderism and Intersexuality in Childhood and Adolescence: Making Choices*. Thousand Oaks, CA: SAGE Publications; 2003.
58. Di Ceglie D, Freedman D, McPherson S, Richardson P. Children and adolescents referred to a specialist gender identity development service: clinical features and demographic characteristics. Available at: https://www.researchgate.net/publication/276061306_Children_and_Adolescents_Referred_to_a_Specialist_Gender_Identity_Development_Service_Clinical_Features_and_Demographic_Characteristics. Accessed 20 July 2017.
59. Gijs L, Brewaeys A. Surgical treatment of gender dysphoria in adults and adolescents: recent developments, effectiveness, and challenges. *Annu Rev Sex Res*. 2007;**18**:178–224.
60. Cohen-Kettenis PT, van Goozen SHM. Sex reassignment of adolescent transsexuals: a follow-up study. *J Am Acad Child Adolesc Psychiatry*. 1997;**36**(2):263–271.
61. Smith YLS, van Goozen SHM, Cohen-Kettenis PT. Adolescents with gender identity disorder who were accepted or rejected for sex reassignment surgery: a prospective follow-up study. *J Am Acad Child Adolesc Psychiatry*. 2001;**40**(4):472–481.
62. Smith YLS, Van Goozen SHM, Kuiper AJ, Cohen-Kettenis PT. Sex reassignment: outcomes and predictors of treatment for adolescent and adult transsexuals. *Psychol Med*. 2005;**35**(1):89–99.
63. de Vries ALC, McGuire JK, Steensma TD, Wagenaar ECF, Doreleijers TAH, Cohen-Kettenis PT. Young adult psychological outcome after puberty suppression and gender reassignment. *Pediatrics*. 2014;**134**(4):696–704.
64. Cole CM, O'Boyle M, Emory LE, Meyer WJ III. Comorbidity of gender dysphoria and other major psychiatric diagnoses. *Arch Sex Behav*. 1997;**26**(1):13–26.
65. Cohen-Kettenis PT, Schagen SEE, Steensma TD, de Vries ALC, Delemarre-van de Waal HA. Puberty suppression in a gender-dysphoric adolescent: a 22-year follow-up. *Arch Sex Behav*. 2011; **40**(4):843–847.
66. First MB. Desire for amputation of a limb: paraphilia, psychosis, or a new type of identity disorder. *Psychol Med*. 2005;**35**(6): 919–928.
67. Wierckx K, Van Caenegem E, Pennings G, Elaut E, Dedecker D, Van de Peer F, Weyers S, De Sutter P, T'Sjoen G. Reproductive wish in transsexual men. *Hum Reprod*. 2012;**27**(2):483–487.
68. Wierckx K, Stuyver I, Weyers S, Hamada A, Agarwal A, De Sutter P, T'Sjoen G. Sperm freezing in transsexual women. *Arch Sex Behav*. 2012;**41**(5):1069–1071.
69. Bertelloni S, Baroncelli GI, Ferdeghini M, Menchini-Fabris F, Saggese G. Final height, gonadal function and bone mineral density of adolescent males with central precocious puberty after therapy with gonadotropin-releasing hormone analogues. *Eur J Pediatr*. 2000;**159**(5):369–374.
70. Büchter D, Behre HM, Kliesch S, Nieschlag E. Pulsatile GnRH or human chorionic gonadotropin/human menopausal gonadotropin as effective treatment for men with hypogonadotropic hypogonadism: a review of 42 cases. *Eur J Endocrinol*. 1998; **139**(3):298–303.
71. Liu PY, Turner L, Rushford D, McDonald J, Baker HW, Conway AJ, Handelsman DJ. Efficacy and safety of recombinant human follicle stimulating hormone (Gonal-F) with urinary human chorionic gonadotrophin for induction of spermatogenesis and fertility in gonadotrophin-deficient men. *Hum Reprod*. 1999; **14**(6):1540–1545.
72. Pasquino AM, Pucarelli I, Accardo F, Demiraj V, Segni M, Di Nardo R. Long-term observation of 87 girls with idiopathic central precocious puberty treated with gonadotropin-releasing hormone analogs: impact on adult height, body mass index, bone mineral content, and reproductive function. *J Clin Endocrinol Metab*. 2008;**93**(1):190–195.
73. Magiakou MA, Manousaki D, Papadaki M, Hadjidakis D, Levidou G, Vakaki M, Papaefstathiou A, Lalioti N, Kanaka-Gantenbein C, Piaditis G, Chrousos GP, Dacou-Voutetakis C. The

efficacy and safety of gonadotropin-releasing hormone analog treatment in childhood and adolescence: a single center, long-term follow-up study. *J Clin Endocrinol Metab*. 2010;**95**(1):109–117.
74. Baba T, Endo T, Honnma H, Kitajima Y, Hayashi T, Ikeda H, Masumori N, Kamiya H, Moriwaka O, Saito T. Association between polycystic ovary syndrome and female-to-male transsexuality. *Hum Reprod*. 2007;**22**(4):1011–1016.
75. Spinder T, Spijkstra JJ, van den Tweel JG, Burger CW, van Kessel H, Hompes PGA, Gooren LJG. The effects of long term testosterone administration on pulsatile luteinizing hormone secretion and on ovarian histology in eugonadal female to male transsexual subjects. *J Clin Endocrinol Metab*. 1989;**69**(1):151–157.
76. Baba T, Endo T, Ikeda K, Shimizu A, Honnma H, Ikeda H, Masumori N, Ohmura T, Kiya T, Fujimoto T, Koizumi M, Saito T. Distinctive features of female-to-male transsexualism and prevalence of gender identity disorder in Japan. *J Sex Med*. 2011;**8**(6):1686–1693.
77. Vujovic S, Popovic S, Sbutega-Milosevic G, Djordjevic M, Gooren L. Transsexualism in Serbia: a twenty-year follow-up study. *J Sex Med*. 2009;**6**(4):1018–1023.
78. Ikeda K, Baba T, Noguchi H, Nagasawa K, Endo T, Kiya T, Saito T. Excessive androgen exposure in female-to-male transsexual persons of reproductive age induces hyperplasia of the ovarian cortex and stroma but not polycystic ovary morphology. *Hum Reprod*. 2013;**28**(2):453–461.
79. Trebay G. He's pregnant. You're speechles. New York Times. 22 June 2008.
80. Light AD, Obedin-Maliver J, Sevelius JM, Kerns JL. Transgender men who experienced pregnancy after female-to-male gender transitioning. *Obstet Gynecol*. 2014;**124**(6):1120–1127.
81. De Sutter P. Donor inseminations in partners of female-to-male transsexuals: should the question be asked? *Reprod Biomed Online*. 2003;**6**(3):382, author reply 282–283.
82. De Roo C, Tilleman K, T'Sjoen G, De Sutter P. Fertility options in transgender people. *Int Rev Psychiatry*. 2016;**28**(1):112–119.
83. Wennink JMB, Delemarre-van de Waal HA, Schoemaker R, Schoemaker H, Schoemaker J. Luteinizing hormone and follicle stimulating hormone secretion patterns in boys throughout puberty measured using highly sensitive immunoradiometric assays. *Clin Endocrinol (Oxf)*. 1989;**31**(5):551–564.
84. Cohen-Kettenis PT, Delemarre-van de Waal HA, Gooren LJG. The treatment of adolescent transsexuals: changing insights. *J Sex Med*. 2008;**5**(8):1892–1897.
85. Delemarre-van de Waal HA, Cohen-Kettenis PT. Clinical management of gender identity disorder in adolescents: a protocol on psychological and paediatric endocrinology aspects. *Eur J Endocrinol*. 2006;**155**:S131–S137.
86. de Vries ALC, Steensma TD, Doreleijers TAH, Cohen-Kettenis PT. Puberty suppression in adolescents with gender identity disorder: a prospective follow-up study. *J Sex Med*. 2011;**8**(8):2276–2283.
87. Bouman MB, van Zeijl MCT, Buncamper ME, Meijerink WJHJ, van Bodegraven AA, Mullender MG. Intestinal vaginoplasty revisited: a review of surgical techniques, complications, and sexual function. *J Sex Med*. 2014;**11**(7):1835–1847.
88. Carel JC, Eugster EA, Rogol A, Ghizzoni L, Palmert MR, Antoniazzi F, Berenbaum S, Bourguignon JP, Chrousos GP, Coste J, Deal S, de Vries L, Foster C, Heger S, Holland J, Jahnukainen K, Juul A, Kaplowitz P, Lahlou N, Lee MM, Lee P, Merke DP, Neely EK, Oostdijk W, Phillip M, Rosenfield RL, Shulman D, Styne D, Tauber M, Wit JM; ESPE-LWPES GnRH Analogs Consensus Conference Group. Consensus statement on the use of gonadotropin-releasing hormone analogs in children. *Pediatrics*. 2009;**123**(4):e752–e762.
89. Roth CL, Brendel L, Rückert C, Hartmann K. Antagonistic and agonistic GnRH analogue treatment of precocious puberty: tracking gonadotropin concentrations in urine. *Horm Res*. 2005;**63**(5):257–262.
90. Roth C. Therapeutic potential of GnRH antagonists in the treatment of precocious puberty. *Expert Opin Investig Drugs*. 2002;**11**(9):1253–1259.
91. Tuvemo T. Treatment of central precocious puberty. *Expert Opin Investig Drugs*. 2006;**15**(5):495–505.
92. Schagen SE, Cohen-Kettenis PT, Delemarre-van de Waal HA, Hannema SE. Efficacy and safety of gonadotropin-releasing hormone agonist treatment to suppress puberty in gender dysphoric adolescents. *J Sex Med*. 2016;**13**(7):1125–1132.
93. Manasco PK, Pescovitz OH, Feuillan PP, Hench KD, Barnes KM, Jones J, Hill SC, Loriaux DL, Cutler GB, Jr. Resumption of puberty after long term luteinizing hormone-releasing hormone agonist treatment of central precocious puberty. *J Clin Endocrinol Metab*. 1988;**67**(2):368–372.
94. Klink D, Caris M, Heijboer A, van Trotsenburg M, Rotteveel J. Bone mass in young adulthood following gonadotropin-releasing hormone analog treatment and cross-sex hormone treatment in adolescents with gender dysphoria. *J Clin Endocrinol Metab*. 2015;**100**(2):E270–E275.
95. Finkelstein JS, Klibanski A, Neer RM. A longitudinal evaluation of bone mineral density in adult men with histories of delayed puberty. *J Clin Endocrinol Metab*. 1996;**81**(3):1152–1155.
96. Bertelloni S, Baroncelli GI, Ferdeghini M, Perri G, Saggese G. Normal volumetric bone mineral density and bone turnover in young men with histories of constitutional delay of puberty. *J Clin Endocrinol Metab*. 1998;**83**(12):4280–4283.
97. Darelid A, Ohlsson C, Nilsson M, Kindblom JM, Mellström D, Lorentzon M. Catch up in bone acquisition in young adult men with late normal puberty. *J Bone Miner Res*. 2012;**27**(10):2198–2207.
98. Mittan D, Lee S, Miller E, Perez RC, Basler JW, Bruder JM. Bone loss following hypogonadism in men with prostate cancer treated with GnRH analogs. *J Clin Endocrinol Metab*. 2002;**87**(8):3656–3661.
99. Saggese G, Bertelloni S, Baroncelli GI, Battini R, Franchi G. Reduction of bone density: an effect of gonadotropin releasing hormone analogue treatment in central precocious puberty. *Eur J Pediatr*. 1993;**152**(9):717–720.
100. Neely EK, Bachrach LK, Hintz RL, Habiby RL, Slemenda CW, Feezle L, Pescovitz OH. Bone mineral density during treatment of central precocious puberty. *J Pediatr*. 1995;**127**(5):819–822.
101. Bertelloni S, Baroncelli GI, Sorrentino MC, Perri G, Saggese G. Effect of central precocious puberty and gonadotropin-releasing hormone analogue treatment on peak bone mass and final height in females. *Eur J Pediatr*. 1998;**157**(5):363–367.
102. Thornton P, Silverman LA, Geffner ME, Neely EK, Gould E, Danoff TM. Review of outcomes after cessation of gonadotropin-releasing hormone agonist treatment of girls with precocious puberty. *Pediatr Endocrinol Rev*. 2014;**11**(3):306–317.
103. Lem AJ, van der Kaay DC, Hokken-Koelega AC. Bone mineral density and body composition in short children born SGA during growth hormone and gonadotropin releasing hormone analog treatment. *J Clin Endocrinol Metab*. 2013;**98**(1):77–86.
104. Antoniazzi F, Zamboni G, Bertoldo F, Lauriola S, Mengarda F, Pietrobelli A, Tatò L. Bone mass at final height in precocious puberty after gonadotropin-releasing hormone agonist with and without calcium supplementation. *J Clin Endocrinol Metab*. 2003;**88**(3):1096–1101.
105. Calcaterra V, Mannarino S, Corana G, Codazzi AC, Mazzola A, Brambilla P, Larizza D. Hypertension during therapy with triptorelin in a girl with precocious puberty. *Indian J Pediatr*. 2013;**80**(10):884–885.
106. Siomou E, Kosmeri C, Pavlou M, Vlahos AP, Argyropoulou MI, Siamopoulou A. Arterial hypertension during treatment with triptorelin in a child with Williams-Beuren syndrome. *Pediatr Nephrol*. 2014;**29**(9):1633–1636.
107. Staphorsius AS, Kreukels BPC, Cohen-Kettenis PT, Veltman DJ, Burke SM, Schagen SEE, Wouters FM, Delemarre-van de Waal

HA, Bakker J. Puberty suppression and executive functioning: an fMRI-study in adolescents with gender dysphoria. *Psychoneuroendocrinology*. 2015;**56**:190–199.
108. Hough D, Bellingham M, Haraldsen IR, McLaughlin M, Rennie M, Robinson JE, Solbakk AK, Evans NP. Spatial memory is impaired by peripubertal GnRH agonist treatment and testosterone replacement in sheep. *Psychoneuroendocrinology*. 2017; **75**:173–182.
109. Collipp PJ, Kaplan SA, Boyle DC, Plachte F, Kogut MD. Constitutional Isosexual Precocious Puberty. *Am J Dis Child*. 1964; **108**:399–405.
110. Hahn HB, Jr, Hayles AB, Albert A. Medroxyprogesterone and constitutional precocious puberty. *Mayo Clin Proc*. 1964;**39**: 182–190.
111. Kaplan SA, Ling SM, Irani NG. Idiopathic isosexual precocity. *Am J Dis Child*. 1968;**116**(6):591–598.
112. Schoen EJ. Treatment of idiopathic precocious puberty in boys. *J Clin Endocrinol Metab*. 1966;**26**(4):363–370.
113. Gooren L. Hormone treatment of the adult transsexual patient. *Horm Res*. 2005;**64**(Suppl 2):31–36.
114. Moore E, Wisniewski A, Dobs A. Endocrine treatment of transsexual people: a review of treatment regimens, outcomes, and adverse effects. *J Clin Endocrinol Metab*. 2003;**88**(8):3467–3473.
115. Krueger RB, Hembree W, Hill M. Prescription of medroxyprogesterone acetate to a patient with pedophilia, resulting in Cushing's syndrome and adrenal insufficiency. *Sex Abuse*. 2006; **18**(2):227–228.
116. Lynch MM, Khandheria MM, Meyer WJ. Retrospective study of the management of childhood and adolescent gender identity disorder using medroxyprogesterone acetate. *Int J Transgenderism*. 2015;**16**:201–208.
117. Tack LJW, Craen M, Dhondt K, Vanden Bossche H, Laridaen J, Cools M. Consecutive lynestrenol and cross-sex hormone treatment in biological female adolescents with gender dysphoria: a retrospective analysis. *Biol Sex Differ*. 2016;**7**:14.
118. Hembree WC, Cohen-Kettenis P, Delemarre-van de Waal HA, Gooren LJ, Meyer WJ 3rd, Spack NP, Tangpricha V, Montori VM; Endocrine Society. Endocrine treatment of transsexual persons: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab*. 2009;**94**(9):3132–3154.
119. Mann L, Harmoni R, Power C. Adolescent decision-making: the development of competence. *J Adolesc*. 1989;**12**(3):265–278.
120. Stultiëns L, Goffin T, Borry P, Dierickx K, Nys H. Minors and informed consent: a comparative approach. *Eur J Health Law*. 2007;**14**(1):21–46.
121. Arshagouni P. "But I'm an adult now … sort of". Adolescent consent in health care decision-making and the adolescent brain. Available at: http://digitalcommons.law.umaryland.edu/cgi/viewcontent.cgi?article=1124&context=jhclp. Accessed 25 June 2017.
122. NHS. Prescribing of cross-sex hormones as part of the gender identity development service for children and adolescents. Available at: https://www.england.nhs.uk/commissioning/wp-content/uploads/sites/12/2016/08/clinical-com-pol-16046p.pdf. Accessed 14 June 2017.
123. Ankarberg-Lindgren C, Kriström B, Norjavaara E. Physiological estrogen replacement therapy for puberty induction in girls: a clinical observational study. *Horm Res Paediatr*. 2014;**81**(4): 239–244.
124. Olson J, Schrager SM, Clark LF, Dunlap SL, Belzer M. Subcutaneous testosterone: an effective delivery mechanism for masculinizing young transgender men. *LGBT Health*. 2014;**1**(3): 165–167.
125. Spratt DI, Stewart I, Savage C, Craig W, Spack NP, Chandler DW, Spratt LV, Eimicke T, Olshan JS. Subcutaneous injection of testosterone is an effective and preferred alternative to intramuscular injection: demonstration in female-to-male transgender patients. *J Clin Endocrinol Metab*. 2017. doi:10.1210/jc.2017-00359
126. Eisenegger C, von Eckardstein A, Fehr E, von Eckardstein S. Pharmacokinetics of testosterone and estradiol gel preparations in healthy young men. *Psychoneuroendocrinology*. 2013;**38**(2): 171–178.
127. de Ronde W, ten Kulve J, Woerdeman J, Kaufman J-M, de Jong FH. Effects of oestradiol on gonadotrophin levels in normal and castrated men. *Clin Endocrinol (Oxf)*. 2009;**71**(6):874–879.
128. Money J, Ehrhardt A. Man & woman, boy & girl: differentiation and dimorphism of gender identity from conception to maturity. Baltimore, MD: Johns Hopkins University Press; 1972:202–206.
129. Heylens G, Verroken C, De Cock S, T'Sjoen G, De Cuypere G. Effects of different steps in gender reassignment therapy on psychopathology: a prospective study of persons with a gender identity disorder. *J Sex Med*. 2014;**11**(1):119–126.
130. Costa R, Colizzi M. The effect of cross-sex hormonal treatment on gender dysphoria individuals' mental health: a systematic review. *Neuropsychiatr Dis Treat*. 2016;**12**:1953–1966.
131. Gooren LJG, Giltay EJ. Review of studies of androgen treatment of female-to-male transsexuals: effects and risks of administration of androgens to females. *J Sex Med*. 2008;**5**(4):765–776.
132. Levy A, Crown A, Reid R. Endocrine intervention for transsexuals. *Clin Endocrinol (Oxf)*. 2003;**59**(4):409–418.
133. Tangpricha V, Ducharme SH, Barber TW, Chipkin SR. Endocrinologic treatment of gender identity disorders. *Endocr Pract*. 2003;**9**(1):12–21.
134. Meriggiola MC, Gava G. Endocrine care of transpeople part I. A review of cross-sex hormonal treatments, outcomes and adverse effects in transmen. *Clin Endocrinol (Oxf)*. 2015;**83**(5):597–606.
135. Bhasin S, Cunningham GR, Hayes FJ, Matsumoto AM, Snyder PJ, Swerdloff RS, Montori VM. Testosterone therapy in adult men with androgen deficiency syndromes: an endocrine society clinical practice guideline. *J Clin Endocrinol Metab*. 2006;**91**(6): 1995–2010.
136. Pelusi C, Costantino A, Martelli V, Lambertini M, Bazzocchi A, Ponti F, Battista G, Venturoli S, Meriggiola MC. Effects of three different testosterone formulations in female-to-male transsexual persons. *J Sex Med*. 2014;**11**(12):3002–3011.
137. Anderson GL, Limacher M, Assaf AR, Bassford T, Beresford SA, Black H, Bonds D, Brunner R, Brzyski R, Caan B, Chlebowski R, Curb D, Gass M, Hays J, Heiss G, Hendrix S, Howard BV, Hsia J, Hubbell A, Jackson R, Johnson KC, Judd H, Kotchen JM, Kuller L, LaCroix AZ, Lane D, Langer RD, Lasser N, Lewis CE, Manson J, Margolis K, Ockene J, O'Sullivan MJ, Phillips L, Prentice RL, Ritenbaugh C, Robbins J, Rossouw JE, Sarto G, Stefanick ML, Van Horn L, Wactawski-Wende J, Wallace R, Wassertheil-Smoller S; Women's Health Initiative Steering Committee. Effects of conjugated equine estrogen in postmenopausal women with hysterectomy: the Women's Health Initiative randomized controlled trial. *JAMA*. 2004;**291**(14):1701–1712.
138. Dickersin K, Munro MG, Clark M, Langenberg P, Scherer R, Frick K, Zhu Q, Hallock L, Nichols J, Yalcinkaya TM; Surgical Treatments Outcomes Project for Dysfunctional Uterine Bleeding (STOP-DUB) Research Group. Hysterectomy compared with endometrial ablation for dysfunctional uterine bleeding: a randomized controlled trial. *Obstet Gynecol*. 2007;**110**(6): 1279–1289.
139. Gooren LJ, Giltay EJ, Bunck MC. Long-term treatment of transsexuals with cross-sex hormones: extensive personal experience. *J Clin Endocrinol Metab*. 2008;**93**(1):19–25.
140. Prior JC, Vigna YM, Watson D. Spironolactone with physiological female steroids for presurgical therapy of male-to-female transsexualism. *Arch Sex Behav*. 1989;**18**(1):49–57.
141. Dittrich R, Binder H, Cupisti S, Hoffmann I, Beckmann MW, Mueller A. Endocrine treatment of male-to-female transsexuals using gonadotropin-releasing hormone agonist. *Exp Clin Endocrinol Diabetes*. 2005;**113**(10):586–592.

142. Stripp B, Taylor AA, Bartter FC, Gillette JR, Loriaux DL, Easley R, Menard RH. Effect of spironolactone on sex hormones in man. *J Clin Endocrinol Metab*. 1975;**41**(4):777–781.
143. Levy J, Burshell A, Marbach M, Afllalo L, Glick SM. Interaction of spironolactone with oestradiol receptors in cytosol. *J Endocrinol*. 1980;**84**(3):371–379.
144. Wierckx K, Elaut E, Van Hoorde B, Heylens G, De Cuypere G, Monstrey S, Weyers S, Hoebeke P, T'Sjoen G. Sexual desire in trans persons: associations with sex reassignment treatment. *J Sex Med*. 2014;**11**(1):107–118.
145. Chiriacò G, Cauci S, Mazzon G, Trombetta C. An observational retrospective evaluation of 79 young men with long-term adverse effects after use of finasteride against androgenetic alopecia. *Andrology*. 2016;**4**(2):245–250.
146. Gava G, Cerpolini S, Martelli V, Battista G, Seracchioli R, Meriggiola MC. Cyproterone acetate vs leuprolide acetate in combination with transdermal oestradiol in transwomen: a comparison of safety and effectiveness. *Clin Endocrinol (Oxf)*. 2016; **85**(2):239–246.
147. Casper RF, Yen SS. Rapid absorption of micronized estradiol-17 beta following sublingual administration. *Obstet Gynecol*. 1981; **57**(1):62–64.
148. Price TM, Blauer KL, Hansen M, Stanczyk F, Lobo R, Bates GW. Single-dose pharmacokinetics of sublingual versus oral administration of micronized 17β-estradiol. *Obstet Gynecol*. 1997;**89**(3): 340–345.
149. Toorians AWFT, Thomassen MCLGD, Zweegman S, Magdeleyns EJP, Tans G, Gooren LJG, Rosing J. Venous thrombosis and changes of hemostatic variables during cross-sex hormone treatment in transsexual people. *J Clin Endocrinol Metab*. 2003;**88**(12): 5723–5729.
150. Mepham N, Bouman WP, Arcelus J, Hayter M, Wylie KR. People with gender dysphoria who self-prescribe cross-sex hormones: prevalence, sources, and side effects knowledge. *J Sex Med*. 2014; **11**(12):2995–3001.
151. Richards C, Bouman WP, Seal L, Barker MJ, Nieder TO, T'Sjoen G. Non-binary or genderqueer genders. *Int Rev Psychiatry*. 2016; **28**(1):95–102.
152. Cosyns M, Van Borsel J, Wierckx K, Dedecker D, Van de Peer F, Daelman T, Laenen S, T'Sjoen G. Voice in female-to-male transsexual persons after long-term androgen therapy. *Laryngoscope*. 2014;**124**(6):1409–1414.
153. Deuster D, Matulat P, Knief A, Zitzmann M, Rosslau K, Szukaj M, am Zehnhoff-Dinnesen A, Schmidt CM. Voice deepening under testosterone treatment in female-to-male gender dysphoric individuals. *Eur Arch Otorhinolaryngol*. 2016;**273**(4):959–965.
154. Lapauw B, Taes Y, Simoens S, Van Caenegem E, Weyers S, Goemaere S, Toye K, Kaufman J-M, T'Sjoen GG. Body composition, volumetric and areal bone parameters in male-to-female transsexual persons. *Bone*. 2008;**43**(6):1016–1021.
155. Meyer III WJ, Webb A, Stuart CA, Finkelstein JW, Lawrence B, Walker PA. Physical and hormonal evaluation of transsexual patients: a longitudinal study. *Arch Sex Behav*. 1986;**15**(2): 121–138.
156. Asscheman H, Gooren LJ, Assies J, Smits JP, de Slegte R. Prolactin levels and pituitary enlargement in hormone-treated male-to-female transsexuals. *Clin Endocrinol (Oxf)*. 1988;**28**(6):583–588.
157. Gooren LJ, Harmsen-Louman W, van Kessel H. Follow-up of prolactin levels in long-term oestrogen-treated male-to-female transsexuals with regard to prolactinoma induction. *Clin Endocrinol (Oxf)*. 1985;**22**(2):201–207.
158. Wierckx K, Van Caenegem E, Schreiner T, Haraldsen I, Fisher AD, Toye K, Kaufman JM, T'Sjoen G. Cross-sex hormone therapy in trans persons is safe and effective at short-time follow-up: results from the European network for the investigation of gender incongruence. *J Sex Med*. 2014;**11**(8):1999–2011.
159. Ott J, Kaufmann U, Bentz EK, Huber JC, Tempfer CB. Incidence of thrombophilia and venous thrombosis in transsexuals under cross-sex hormone therapy. *Fertil Steril*. 2010;**93**(4):1267–1272.
160. Giltay EJ, Hoogeveen EK, Elbers JMH, Gooren LJG, Asscheman H, Stehouwer CDA. Effects of sex steroids on plasma total homocysteine levels: a study in transsexual males and females. *J Clin Endocrinol Metab*. 1998;**83**(2):550–553.
161. van Kesteren PJM, Asscheman H, Megens JAJ, Gooren LJG. Mortality and morbidity in transsexual subjects treated with cross-sex hormones. *Clin Endocrinol (Oxf)*. 1997;**47**(3): 337–343.
162. Wierckx K, Gooren L, T'Sjoen G. Clinical review: breast development in trans women receiving cross-sex hormones. *J Sex Med*. 2014;**11**(5):1240–1247.
163. Bird D, Vowles K, Anthony PP. Spontaneous rupture of a liver cell adenoma after long term methyltestosterone: report of a case successfully treated by emergency right hepatic lobectomy. *Br J Surg*. 1979;**66**(3):212–213.
164. Westaby D, Ogle SJ, Paradinas FJ, Randell JB, Murray-Lyon IM. Liver damage from long-term methyltestosterone. *Lancet*. 1977; **2**(8032):262–263.
165. Weinand JD, Safer JD. Hormone therapy in transgender adults is safe with provider supervision; a review of hormone therapy sequelae for transgender individuals. *J Clin Transl Endocrinol*. 2015;**2**(2):55–60.
166. Roberts TK, Kraft CS, French D, Ji W, Wu AH, Tangpricha V, Fantz CR. Interpreting laboratory results in transgender patients on hormone therapy. *Am J Med*. 2014;**127**(2):159–162.
167. Vesper HW, Botelho JC, Wang Y. Challenges and improvements in testosterone and estradiol testing. *Asian J Androl*. 2014;**16**(2): 178–184.
168. Asscheman H, T'Sjoen G, Lemaire A, Mas M, Meriggiola MC, Mueller A, Kuhn A, Dhejne C, Morel-Journel N, Gooren LJ. Venous thrombo-embolism as a complication of cross-sex hormone treatment of male-to-female transsexual subjects: a review. *Andrologia*. 2014;**46**(7):791–795.
169. Righini M, Perrier A, De Moerloose P, Bounameaux H. D-dimer for venous thromboembolism diagnosis: 20 years later. *J Thromb Haemost*. 2008;**6**(7):1059–1071.
170. Gooren LJ, Assies J, Asscheman H, de Slegte R, van Kessel H. Estrogen-induced prolactinoma in a man. *J Clin Endocrinol Metab*. 1988;**66**(2):444–446.
171. Kovacs K, Stefaneanu L, Ezzat S, Smyth HS. Prolactin-producing pituitary adenoma in a male-to-female transsexual patient with protracted estrogen administration. A morphologic study. *Arch Pathol Lab Med*. 1994;**118**(5):562–565.
172. Serri O, Noiseux D, Robert F, Hardy J. Lactotroph hyperplasia in an estrogen treated male-to-female transsexual patient. *J Clin Endocrinol Metab*. 1996;**81**(9):3177–3179.
173. Cunha FS, Domenice S, Câmara VL, Sircili MH, Gooren LJ, Mendonça BB, Costa EM. Diagnosis of prolactinoma in two male-to-female transsexual subjects following high-dose cross-sex hormone therapy. *Andrologia*. 2015;**47**(6):680–684.
174. Nota NM, Dekker MJHJ, Klaver M, Wiepjes CM, van Trotsenburg MA, Heijboer AC, den Heijer M. Prolactin levels during short- and long-term cross-sex hormone treatment: an observational study in transgender persons. *Andrologia*. 2017;**49**(6).
175. Bunck MC, Debono M, Giltay EJ, Verheijen AT, Diamant M, Gooren LJ. Autonomous prolactin secretion in two male-to-female transgender patients using conventional oestrogen dosages. *BMJ Case Rep*. 2009;**2009**:bcr0220091589.
176. Elamin MB, Garcia MZ, Murad MH, Erwin PJ, Montori VM. Effect of sex steroid use on cardiovascular risk in transsexual individuals: a systematic review and meta-analyses. *Clin Endocrinol (Oxf)*. 2010;**72**(1):1–10.
177. Berra M, Armillotta F, D'Emidio L, Costantino A, Martorana G, Pelusi G, Meriggiola MC. Testosterone decreases adiponectin

levels in female to male transsexuals. *Asian J Androl*. 2006;**8**(6):725–729.
178. Elbers JMH, Giltay EJ, Teerlink T, Scheffer PG, Asscheman H, Seidell JC, Gooren LJG. Effects of sex steroids on components of the insulin resistance syndrome in transsexual subjects. *Clin Endocrinol (Oxf)*. 2003;**58**(5):562–571.
179. Giltay EJ, Lambert J, Gooren LJG, Elbers JMH, Steyn M, Stehouwer CDA. Sex steroids, insulin, and arterial stiffness in women and men. *Hypertension*. 1999;**34**(4 Pt 1):590–597.
180. Polderman KH, Gooren LJ, Asscheman H, Bakker A, Heine RJ. Induction of insulin resistance by androgens and estrogens. *J Clin Endocrinol Metab*. 1994;**79**(1):265–271.
181. Maraka S. Effect of sex steroids on lipids, venous thromboembolism, cardiovascular disease and mortality in transgender individuals: a systematic review and meta-analysis. Available at: http://press.endocrine.org/doi/abs/10.1210/endo-meetings.2016.RE.15.FRI-136. Accessed 3 July 2017.
182. Meriggiola MC, Armillotta F, Costantino A, Altieri P, Saad F, Kalhorn T, Perrone AM, Ghi T, Pelusi C, Pelusi G. Effects of testosterone undecanoate administered alone or in combination with letrozole or dutasteride in female to male transsexuals. *J Sex Med*. 2008;**5**(10):2442–2453.
183. Giltay EJ, Toorians AW, Sarabdjitsingh AR, de Vries NA, Gooren LJ. Established risk factors for coronary heart disease are unrelated to androgen-induced baldness in female-to-male transsexuals. *J Endocrinol*. 2004;**180**(1):107–112.
184. Giltay EJ, Verhoef P, Gooren LJG, Geleijnse JM, Schouten EG, Stehouwer CDA. Oral and transdermal estrogens both lower plasma total homocysteine in male-to-female transsexuals. *Atherosclerosis*. 2003;**168**(1):139–146.
185. Calof OM, Singh AB, Lee ML, Kenny AM, Urban RJ, Tenover JL, Bhasin S. Adverse events associated with testosterone replacement in middle-aged and older men: a meta-analysis of randomized, placebo-controlled trials. *J Gerontol A Biol Sci Med Sci*. 2005;**60**(11):1451–1457.
186. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). *JAMA*. 2001;**285**(19):2486–2497.
187. Murad MH, Elamin MB, Garcia MZ, Mullan RJ, Murad A, Erwin PJ, Montori VM. Hormonal therapy and sex reassignment: a systematic review and meta-analysis of quality of life and psychosocial outcomes. *Clin Endocrinol (Oxf)*. 2010;**72**(2):214–231.
188. Van Caenegem E, Wierckx K, Taes Y, Schreiner T, Vandewalle S, Toye K, Lapauw B, Kaufman JM, T'Sjoen G. Body composition, bone turnover, and bone mass in trans men during testosterone treatment: 1-year follow-up data from a prospective case-controlled study (ENIGI). *Eur J Endocrinol*. 2015;**172**(2):163–171.
189. Turner A, Chen TC, Barber TW, Malabanan AO, Holick MF, Tangpricha V. Testosterone increases bone mineral density in female-to-male transsexuals: a case series of 15 subjects. *Clin Endocrinol (Oxf)*. 2004;**61**(5):560–566.
190. van Kesteren P, Lips P, Gooren LJG, Asscheman H, Megens J. Long-term follow-up of bone mineral density and bone metabolism in transsexuals treated with cross-sex hormones. *Clin Endocrinol (Oxf)*. 1998;**48**(3):347–354.
191. Van Caenegem E, Taes Y, Wierckx K, Vandewalle S, Toye K, Kaufman JM, Schreiner T, Haraldsen I, T'Sjoen G. Low bone mass is prevalent in male-to-female transsexual persons before the start of cross-sex hormonal therapy and gonadectomy. *Bone*. 2013;**54**(1):92–97.
192. Amin S, Zhang Y, Sawin CT, Evans SR, Hannan MT, Kiel DP, Wilson PW, Felson DT. Association of hypogonadism and estradiol levels with bone mineral density in elderly men from the Framingham study. *Ann Intern Med*. 2000;**133**(12):951–963.
193. Gennari L, Khosla S, Bilezikian JP. Estrogen and fracture risk in men. *J Bone Miner Res*. 2008;**23**(10):1548–1551.
194. Khosla S, Melton LJ III, Atkinson EJ, O'Fallon WM, Klee GG, Riggs BL. Relationship of serum sex steroid levels and bone turnover markers with bone mineral density in men and women: a key role for bioavailable estrogen. *J Clin Endocrinol Metab*. 1998;**83**(7):2266–2274.
195. Mueller A, Dittrich R, Binder H, Kuehnel W, Maltaris T, Hoffmann I, Beckmann MW. High dose estrogen treatment increases bone mineral density in male-to-female transsexuals receiving gonadotropin-releasing hormone agonist in the absence of testosterone. *Eur J Endocrinol*. 2005;**153**(1):107–113.
196. Ruetsche AG, Kneubuehl R, Birkhaeuser MH, Lippuner K. Cortical and trabecular bone mineral density in transsexuals after long-term cross-sex hormonal treatment: a cross-sectional study. *Osteoporos Int*. 2005;**16**(7):791–798.
197. Ganly I, Taylor EW. Breast cancer in a trans-sexual man receiving hormone replacement therapy. *Br J Surg*. 1995;**82**(3):341.
198. Pritchard TJ, Pankowsky DA, Crowe JP, Abdul-Karim FW. Breast cancer in a male-to-female transsexual. A case report. *JAMA*. 1988;**259**(15):2278–2280.
199. Symmers WS. Carcinoma of breast in trans-sexual individuals after surgical and hormonal interference with the primary and secondary sex characteristics. *BMJ*. 1968;**2**(5597):83–85.
200. Brown GR. Breast cancer in transgender veterans: a ten-case series. *LGBT Health*. 2015;**2**(1):77–80.
201. Shao T, Grossbard ML, Klein P. Breast cancer in female-to-male transsexuals: two cases with a review of physiology and management. *Clin Breast Cancer*. 2011;**11**(6):417–419.
202. Nikolic DV, Djordjevic ML, Granic M, Nikolic AT, Stanimirovic VV, Zdravkovic D, Jelic S. Importance of revealing a rare case of breast cancer in a female to male transsexual after bilateral mastectomy. *World J Surg Oncol*. 2012;**10**:280.
203. Bösze P, Tóth A, Török M. Hormone replacement and the risk of breast cancer in Turner's syndrome. *N Engl J Med*. 2006;**355**(24):2599–2600.
204. Schoemaker MJ, Swerdlow AJ, Higgins CD, Wright AF, Jacobs PA; UK Clinical Cytogenetics Group. Cancer incidence in women with Turner syndrome in Great Britain: a national cohort study. *Lancet Oncol*. 2008;**9**(3):239–246.
205. Smith RA, Cokkinides V, Eyre HJ. American Cancer Society guidelines for the early detection of cancer, 2006. *CA Cancer J Clin*. 2006;**56**(1):11–25, quiz 49–50.
206. Wilson JD, Roehrborn C. Long-term consequences of castration in men: lessons from the Skoptzy and the eunuchs of the Chinese and Ottoman courts. *J Clin Endocrinol Metab*. 1999;**84**(12):4324–4331.
207. van Kesteren P, Meinhardt W, van der Valk P, Geldof A, Megens J, Gooren L. Effects of estrogens only on the prostates of aging men. *J Urol*. 1996;**156**(4):1349–1353.
208. Brown JA, Wilson TM. Benign prostatic hyperplasia requiring transurethral resection of the prostate in a 60-year-old male-to-female transsexual. *Br J Urol*. 1997;**80**(6):956–957.
209. Casella R, Bubendorf L, Schaefer DJ, Bachmann A, Gasser TC, Sulser T. Does the prostate really need androgens to grow? Transurethral resection of the prostate in a male-to-female transsexual 25 years after sex-changing operation. *Urol Int*. 2005;**75**(3):288–290.
210. Dorff TB, Shazer RL, Nepomuceno EM, Tucker SJ. Successful treatment of metastatic androgen-independent prostate carcinoma in a transsexual patient. *Clin Genitourin Cancer*. 2007;**5**(5):344–346.
211. Thurston AV. Carcinoma of the prostate in a transsexual. *Br J Urol*. 1994;**73**(2):217.

212. van Harst EP, Newling DW, Gooren LJ, Asscheman H, Prenger DM. Metastatic prostatic carcinoma in a male-to-female transsexual. *BJU Int*. 1998;**81**:776.
213. Turo R, Jallad S, Prescott S, Cross WR. Metastatic prostate cancer in transsexual diagnosed after three decades of estrogen therapy. *Can Urol Assoc J*. 2013;**7**(7–8):E544–E546.
214. Miksad RA, Bubley G, Church P, Sanda M, Rofsky N, Kaplan I, Cooper A. Prostate cancer in a transgender woman 41 years after initiation of feminization. *JAMA*. 2006;**296**(19):2316–2317.
215. Moyer VA; U.S. Preventive Services Task Force. Screening for prostate cancer: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med*. 2012;**157**(2):120–134.
216. Futterweit W. Endocrine therapy of transsexualism and potential complications of long-term treatment. *Arch Sex Behav*. 1998; **27**(2):209–226.
217. Miller N, Bédard YC, Cooter NB, Shaul DL. Histological changes in the genital tract in transsexual women following androgen therapy. *Histopathology*. 1986;**10**(7):661–669.
218. O'Hanlan KA, Dibble SL, Young-Spint M. Total laparoscopic hysterectomy for female-to-male transsexuals. *Obstet Gynecol*. 2007;**110**(5):1096–1101.
219. Dizon DS, Tejada-Berges T, Koelliker S, Steinhoff M, Granai CO. Ovarian cancer associated with testosterone supplementation in a female-to-male transsexual patient. *Gynecol Obstet Invest*. 2006; **62**(4):226–228.
220. Hage JJ, Dekker JJML, Karim RB, Verheijen RHM, Bloemena E. Ovarian cancer in female-to-male transsexuals: report of two cases. *Gynecol Oncol*. 2000;**76**(3):413–415.
221. Mueller A, Gooren L. Hormone-related tumors in transsexuals receiving treatment with cross-sex hormones. *Eur J Endocrinol*. 2008;**159**(3):197–202.
222. Coleman E, Bockting W, Botzer M, Cohen-Kettenis P, DeCuypere G, Feldman J, Fraser L, Green J, Knudson G, Meyer WJ, Monstrey S, Adler RK, Brown GR, Devor AH, Ehrbar R, Ettner R, Eyler E, Garofalo R, Karasic DH, Lev AI, Mayer G, Meyer-Bahlburg H, Hall BP, Pfaefflin F, Rachlin K, Robinson B, Schechter LS, Tangpricha V, van Trotsenburg M, Vitale A, Winter S, Whittle S, Wylie KR, Zucker K. Standards of care for the health of transsexual, transgender, and gender-nonconforming people, version 7. *Int J Transgenderism*. 2012;**13**:165–232.
223. Colebunders B, D'Arpa S, Weijers S, Lumen N, Hoebeke P, Monstrey S. Female-to-male gender reassignment surgery. In: Ettner R, Monstrey S, Coleman E, eds. *Principles of Transgender Medicine and Surgery*. 2nd ed. New York, NY: Routledge Taylor & Francis Group; 2016:279–317.
224. Monstrey S, Hoebeke P, Dhont M, De Cuypere G, Rubens R, Moerman M, Hamdi M, Van Landuyt K, Blondeel P. Surgical therapy in transsexual patients: a multi-disciplinary approach. *Acta Chir Belg*. 2001;**101**(5):200–209.
225. Selvaggi G, Ceulemans P, De Cuypere G, VanLanduyt K, Blondeel P, Hamdi M, Bowman C, Monstrey S. Gender identity disorder: general overview and surgical treatment for vaginoplasty in male-to-female transsexuals. *Plast Reconstr Surg*. 2005;**116**(6): 135e–145e.
226. Tugnet N, Goddard JC, Vickery RM, Khoosal D, Terry TR. Current management of male-to-female gender identity disorder in the UK. *Postgrad Med J*. 2007;**83**(984):638–642.
227. Horbach SER, Bouman M-B, Smit JM, Özer M, Buncamper ME, Mullender MG. Outcome of vaginoplasty in male-to-female transgenders: a systematic review of surgical techniques. *J Sex Med*. 2015;**12**(6):1499–1512.
228. Wroblewski P, Gustafsson J, Selvaggi G. Sex reassignment surgery for transsexuals. *Curr Opin Endocrinol Diabetes Obes*. 2013; **20**(6):570–574.
229. Morrison SD, Satterwhite T, Grant DW, Kirby J, Laub DR, Sr, VanMaasdam J. Long-term outcomes of rectosigmoid neocolporrhaphy in male-to-female gender reassignment surgery. *Plast Reconstr Surg*. 2015;**136**(2):386–394.
230. Dessy LA, Mazzocchi M, Corrias F, Ceccarelli S, Marchese C, Scuderi N. The use of cultured autologous oral epithelial cells for vaginoplasty in male-to-female transsexuals: a feasibility, safety, and advantageousness clinical pilot study. *Plast Reconstr Surg*. 2014;**133**(1):158–161.
231. Li FY, Xu YS, Zhou CD, Zhou Y, Li SK, Li Q. Long-term outcomes of vaginoplasty with autologous buccal micromucosa. *Obstet Gynecol*. 2014;**123**(5):951–956.
232. Kanhai RC. Sensate vagina pedicled-spot for male-to-female transsexuals: the experience in the first 50 patients. *Aesthetic Plast Surg*. 2016;**40**(2):284–287.
233. Straayer C. Transplants for transsexuals? Ambitions, concerns, ideology. Paper presented at: Trans*Studies: An International Transdisciplinary Conference on Gender, Embodiment, and Sexuality; 7–10 September 2016; University of Arizona, Tucson, AZ.
234. Bucci S, Mazzon G, Liguori G, Napoli R, Pavan N, Bormioli S, Ollandini G, De Concilio B, Trombetta C. Neovaginal prolapse in male-to-female transsexuals: an 18-year-long experience. *Biomed Res Int*. 2014;**2014**:240761.
235. Raigosa M, Avvedimento S, Yoon TS, Cruz-Gimeno J, Rodriguez G, Fontdevila J. Male-to-female genital reassignment surgery: a retrospective review of surgical technique and complications in 60 patients. *J Sex Med*. 2015;**12**(8):1837–1845.
236. Green R. Sexual functioning in post-operative transsexuals: male-to-female and female-to-male. *Int J Impot Res*. 1998;**10**(Suppl 1): S22–S24.
237. Hess J, Rossi Neto R, Panic L, Rübben H, Senf W. Satisfaction with male-to-female gender reassignment surgery. *Dtsch Arztebl Int*. 2014;**111**(47):795–801.
238. Nygren U, Nordenskjold A, Arver S, Sodersten M. Effects on voice fundamental frequency and satisfaction with voice in trans men during testosterone treatment—a longitudinal study. *J Voice*. 2016;**30**(6):766.e23-766.e34.
239. Becking AG, Tuinzing DB, Hage JJ, Gooren LJG. Transgender feminization of the facial skeleton. *Clin Plast Surg*. 2007;**34**(3): 557–564.
240. Giraldo F, Esteva I, Bergero T, Cano G, González C, Salinas P, Rivada E, Lara JS, Soriguer F; Andalusia Gender Team. Corona glans clitoroplasty and urethropreputial vestibuloplasty in male-to-female transsexuals: the vulval aesthetic refinement by the Andalusia Gender Team. *Plast Reconstr Surg*. 2004;**114**(6): 1543–1550.
241. Goddard JC, Vickery RM, Terry TR. Development of feminizing genitoplasty for gender dysphoria. *J Sex Med*. 2007;**4**(4 Pt 1): 981–989.
242. Hage JJ, de Graaf FH, Bouman FG, Bloem JJAM. Sculpturing the glans in phalloplasty. *Plast Reconstr Surg*. 1993;**92**(1):157–161, discussion 162.
243. Thiagaraj D, Gunasegaram R, Loganath A, Peh KL, Kottegoda SR, Ratnam SS. Histopathology of the testes from male transsexuals on oestrogen therapy. *Ann Acad Med Singapore*. 1987; **16**(2):347–348.
244. Monstrey SJ, Ceulemans P, Hoebeke P. Sex reassignment surgery in the female-to-male transsexual. *Semin Plast Surg*. 2011;**25**(3): 229–244.
245. Perovic SV, Djinovic R, Bumbasirevic M, Djordjevic M, Vukovic P. Total phalloplasty using a musculocutaneous latissimus dorsi flap. *BJU Int*. 2007;**100**(4):899–905, discussion 905.
246. Vesely J, Hyza P, Ranno R, Cigna E, Monni N, Stupka I, Justan I, Dvorak Z, Novak P, Ranno S. New technique of total phalloplasty with reinnervated latissimus dorsi myocutaneous free flap in female-to-male transsexuals. *Ann Plast Surg*. 2007;**58**(5): 544–550.
247. Ranno R, Veselý J, Hýza P, Stupka I, Justan I, Dvorák Z, Monni N, Novák P, Ranno S. Neo-phalloplasty with re-innervated latissimus dorsi free flap: a functional study of a novel technique. *Acta Chir Plast*. 2007;**49**(1):3–7.

248. Garcia MM, Christopher NA, De Luca F, Spilotros M, Ralph DJ. Overall satisfaction, sexual function, and the durability of neophallus dimensions following staged female to male genital gender confirming surgery: the Institute of Urology, London U.K. experience. *Transl Androl Urol*. 2014;**3**(2):156–162.
249. Chen H-C, Gedebou TM, Yazar S, Tang Y-B. Prefabrication of the free fibula osteocutaneous flap to create a functional human penis using a controlled fistula method. *J Reconstr Microsurg*. 2007;**23**(3):151–154.
250. Hoebeke PB, Decaestecker K, Beysens M, Opdenakker Y, Lumen N, Monstrey SM. Erectile implants in female-to-male transsexuals: our experience in 129 patients. *Eur Urol*. 2010;**57**(2):334–341.
251. Hage JJ. Metaidoioplasty: an alternative phalloplasty technique in transsexuals. *Plast Reconstr Surg*. 1996;**97**(1):161–167.
252. Cohanzad S. Extensive metoidioplasty as a technique capable of creating a compatible analogue to a natural penis in female transsexuals. *Aesthetic Plast Surg*. 2016;**40**(1):130–138.
253. Selvaggi G, Hoebeke P, Ceulemans P, Hamdi M, Van Landuyt K, Blondeel P, De Cuypere G, Monstrey S. Scrotal reconstruction in female-to-male transsexuals: a novel scrotoplasty. *Plast Reconstr Surg*. 2009;**123**(6):1710–1718.
254. Bjerrome Ahlin H, Kölby L, Elander A, Selvaggi G. Improved results after implementation of the Ghent algorithm for subcutaneous mastectomy in female-to-male transsexuals. *J Plast Surg Hand Surg*. 2014;**48**(6):362–367.
255. Wolter A, Diedrichson J, Scholz T, Arens-Landwehr A, Liebau J. Sexual reassignment surgery in female-to-male transsexuals: an algorithm for subcutaneous mastectomy. *J Plast Reconstr Aesthet Surg*. 2015;**68**(2):184–191.
256. Richards C, Barrett J. The case for bilateral mastectomy and male chest contouring for the female-to-male transsexual. *Ann R Coll Surg Engl*. 2013;**95**(2):93–95.
257. Sutcliffe PA, Dixon S, Akehurst RL, Wilkinson A, Shippam A, White S, Richards R, Caddy CM. Evaluation of surgical procedures for sex reassignment: a systematic review. *J Plast Reconstr Aesthet Surg*. 2009;**62**(3):294–306, discussion 306–308.
258. Selvaggi G, Elander A. Penile reconstruction/formation. *Curr Opin Urol*. 2008;**18**(6):589–597.
259. Dhejne C, Lichtenstein P, Boman M, Johansson ALV, Långström N, Landén M. Long-term follow-up of transsexual persons undergoing sex reassignment surgery: cohort study in Sweden. *PLoS One*. 2011;**6**(2):e16885.
260. Kuhn A, Bodmer C, Stadlmayr W, Kuhn P, Mueller MD, Birkhäuser M. Quality of life 15 years after sex reassignment surgery for transsexualism. *Fertil Steril*. 2009;**92**(5):1685–1689.e3.
261. Papadopulos NA, Lellé JD, Zavlin D, Herschbach P, Henrich G, Kovacs L, Ehrenberger B, Kluger AK, Machens HG, Schaff J. Quality of life and patient satisfaction following male-to-female sex reassignment surgery. *J Sex Med*. 2017;**14**(5):721–730.
262. Simonsen RK, Hald GM, Kristensen E, Giraldi A. Long-term follow-up of individuals undergoing sex-reassignment surgery: somatic morbidity and cause of death. *Sex Med*. 2016;**4**(1):e60–e68.
263. Djordjevic ML, Bizic MR, Duisin D, Bouman MB, Buncamper M. Reversal Surgery in regretful male-to-female transsexuals after sex reassignment surgery. *J Sex Med*. 2016;**13**(6):1000–1007.
264. Liberopoulos EN, Florentin M, Mikhailidis DP, Elisaf MS. Compliance with lipid-lowering therapy and its impact on cardiovascular morbidity and mortality. *Expert Opin Drug Saf*. 2008;**7**(6):717–725.
265. Forbes SS, Stephen WJ, Harper WL, Loeb M, Smith R, Christoffersen EP, McLean RF. Implementation of evidence-based practices for surgical site infection prophylaxis: results of a pre- and postintervention study. *J Am Coll Surg*. 2008;**207**(3):336–341.
266. Davis PJ, Spady D, de Gara C, Forgie SE. Practices and attitudes of surgeons toward the prevention of surgical site infections: a provincial survey in Alberta, Canada. *Infect Control Hosp Epidemiol*. 2008;**29**(12):1164–1166.