

# On Treating Athletes with Banned Substances: The Relationship Between Mild Traumatic Brain Injury, Hypopituitarism, and Hormone Replacement Therapy

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**Abstract** Until recently, the problem of traumatic brain injury in sports and the problem of performance enhancement via hormone replacement have not been seen as related issues. However, recent evidence suggests that these two problems may actually interact in complex and previously underappreciated ways. A body of recent research has shown that traumatic brain injuries (TBI), at all ranges of severity, have a negative effect upon pituitary function, which results in diminished levels of several endogenous hormones, such as growth hormone and gonadotropin. This is a cause for concern for many popular sports that have high rates of concussion, a mild form of TBI. Emerging research suggests that hormone replacement therapy is an effective treatment for TBI-related hormone deficiency. However, many athletic organizations ban or severely limit the use of hormone replacing substances because many athletes seek to use them solely for the purposes of performance enhancement. Nevertheless, in the light of the research linking

traumatic brain injury to hypopituitarism, this paper argues that athletic organizations' policies and attitudes towards hormone replacement therapy should change. We defend two claims. First, because of the connection between TBI and pituitary function, it is likely many more athletes than previously acknowledged suffer from hormone deficiency and thus could benefit from hormone replacement therapy. Second, athletes' hormone levels should be tested more rigorously and frequently with an emphasis on monitoring TBI and TBI-related issues, rather than simply monitoring policy violations.

**Keywords** Biomedical ethics · Concussions · Traumatic brain injury · Sports · Enhancement · Hormones

## Introduction

Until recently, the problem of traumatic brain injury (TBI) in sports and the problem of performance enhancement via hormone replacement have not been seen as related issues. However, recent evidence suggests that these two problems may actually interact in complex and previously underappreciated ways.<sup>1</sup> A body of recent research has shown that TBIs, at all ranges of severity, have a negative effect upon pituitary function, which results in diminished levels of several endogenous

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<sup>1</sup> For instance, in the *British Journal of Sports Medicine's* "Consensus Statement on Concussion in Sports" there is no mention of this issue, nor is there any mention throughout the entire issue, despite the fact that it is dedicated to concussion in sports [51].

hormones, such as growth hormone (GH) and gonadotropin [1–8]. Furthermore, emerging research suggests that hormone replacement therapy (HRT) is an effective treatment for symptoms caused by TBI-related hormone deficiency [9–12]. This poses a unique problem for sports that bear a high risk of TBIs, such as American football, ice-hockey, rugby, soccer, kickboxing, and mixed martial arts (MMA) [13, 14]. The organizations that sanction these sports generally prohibit the use of hormones such as testosterone and human growth hormone by athletes. However, it is possible for athletes to obtain a therapeutic use exemption (TUE), which allows the athlete to take a prohibited drug for therapeutic reasons. Nevertheless, because many athletes do, in fact, want to take hormone elevating drugs in order to increase their performance, but do not want to violate league policy, the current situation has invited the suspicion that athletes may be abusing the policy and obtaining TUEs solely for performance enhancement. This suspicion has led sports organizations to reconsider granting TUEs for hormone replacement therapies altogether. For example, the Association of Ringside Physicians (ARP), an international, non-profit organization that oversees the safety of boxers and mixed martial artists, has recently called for the “general elimination of TUE for testosterone replacement therapy (TRT)” [15]. The ARP claims that contact athletes legitimately requiring TRT are “extraordinarily rare” [15], and so there is little to gain for allowing the current TUE policy to continue.<sup>2</sup>

In this paper, we challenge this line of thinking by arguing that in light of research on TBI and HRT, policies and attitudes towards HRT should change. More precisely, we defend two claims: (1) Because of the connection between TBIs and pituitary function, it is likely many more athletes than previously acknowledged suffer from neuroendocrine dysfunction and thus could benefit from HRT. (2) Athletes’ hormone levels should be tested more rigorously and frequently with an emphasis on monitoring TBI and TBI related issues, rather than on simply monitoring policy violations.

The structure of this paper is as follows. First, we discuss the occurrence of TBIs in sports and how this can cause neuroendocrine dysfunction. Second, we explain how HRT is a viable option for treating the kinds of hormone deficiencies often associated with TBI. Third, we discuss how this research should affect policy

concerning the use of banned substances in sports that bear a high risk of TBI. Finally, we address a potential objection to our proposal.

### Traumatic Brain Injury, Hormone Levels, and Sports

TBI occurs when an external force, such as impact or rapid acceleration or deceleration, damages the brain and disrupts brain function. TBIs are often categorized based on severity using scales that evaluate level of consciousness, amount of disorientation, and loss of consciousness. An estimated 20 % of the 1.7 million diagnosed TBIs per year are classified as moderate or severe, with the remaining 80 % being cases of mild TBI [16]. Concussion, a form of mild TBI, often presents with symptoms of confusion, transient loss of consciousness, and an inability to remember the events prior to or following the TBI [17]. Although TBIs, especially mild ones, have traditionally been thought of as one-time events with short-term consequences, research in recent decades suggests that TBIs can have long lasting and widespread effects on cognition, mood, and neurological health [17].

One of the long-term effects of TBIs that has recently been acknowledged is chronic hypopituitarism, a disease characterized by decreased secretion of one or more of the major hormones that are produced by the pituitary gland. These hormones include GH, which stimulates growth of various body tissues and the gonadotropins, which, among other things, stimulate the production of testosterone. Hypopituitarism thus results in a deficiency of hormones that control many important processes in the body, and so the disease can present with a variety of symptoms. Symptoms vary depending on which hormones are deficient, but can include fatigue, weakness, weight loss or gain, decreased muscle mass, osteoporosis, and decreased sex drive. Importantly for the purposes of this paper, many of the hormones that may be deficient in hypopituitarism are hormones that, when elevated, can enhance athletic performance.

Although the connection between TBI and pituitary dysfunction was recognized in the early 1900’s, the frequency of hormonal disturbance following TBI has only recently begun to be appreciated [18]. The reported association between cases of hypopituitarism and previous TBI varies widely across studies, from 5.4 to 69 % [1–8]. In a meta-analysis that pooled across 13 different studies, the prevalence of hypopituitarism following

<sup>2</sup> As of February 27, 2014 the Nevada State Athletic Commission no longer considers applications for TUEs for TRT [52].

TBI was found to be 27.5 % [19]. However, many of these studies have relied upon patient reports of previously experienced TBIs, and TBIs, especially mild ones, often go unnoticed and unreported [20]. This problem is further compounded by the fact that the symptoms of pituitary dysfunction can be subtle, and often overlap with the symptoms of TBI [19]. A diagnosis of hypopituitarism following TBI can thus be easily missed. More controlled research that has followed patients who were admitted to a hospital for TBI has shown that 54 % of patients who had a TBI within the past 5 years developed pituitary dysfunction [3]. Furthermore, pituitary dysfunction can persist for a long period after the TBI: symptoms of hypopituitarism have been shown to be present at one, three, and five years following a TBI [21–23], and although some patients experience an improvement of symptoms within this time frame, others worsen. TBI-induced hypopituitarism thus appears to be a common phenomenon that can last for several years following a TBI.

The most surprising aspect of this research, however, is the fact that even mild TBIs have been associated with hypopituitarism at a relatively high frequency. Bondanelli et al. [3] found that 39.4 % of patients with mild TBIs later developed pituitary dysfunction (compared to 59.3 % with severe TBI) [3]. Other research suggests that there is no association between the severity of a TBI and the later development of hormone deficiency [6–8, 21, 24]. In other words, TBIs are associated with lessened hormone levels, and this association does not depend upon how severe the TBI was. Because mild TBIs, including concussions, are relatively common in contact sports, these studies suggest that athletes participating in such sports are at risk for developing hormonal deficiencies associated with TBIs.

Though there is a paucity of data directly linking hypopituitarism and sports-related TBIs, several studies suggest that there is an association. In a study on competing and retired amateur boxers, 45 % of the boxers were shown to have significantly lower GH levels than controls [25]. These results also showed a negative correlation between the number of matches the boxers have had and their GH levels, suggesting that the more times they had put themselves in a situation in which TBIs were likely to occur, the less GH they had. An additional study corroborated these results, showing that 18 % of active boxers and 47 % of retired boxers had hypopituitarism [26]. A study of kickboxers revealed that 22.7 % of the athletes had lower level of

GH and of adrenocorticotropin-releasing hormone than controls, and that levels of insulin-like growth factor-1, a hormone whose production is stimulated by GH, were negatively correlated with the length of time participating in the sport and number of bouts participated in [27]. Finally, two case studies have argued for a connection between sports-related head trauma and pituitary dysfunction. In one case, a 16-year old soccer player received four mild TBIs within a 4 months period. Over the course of the year following these TBIs, the patient showed a lack of physical growth and improvement in athletic skills and overall diminished energy levels. When tested, he showed deficiencies in several hormones, including GH and adrenocorticotropin, which resulted in a diagnosis of hypopituitarism [28]. In a second case, a 24-year old swimmer was hospitalized after hitting her head on the side of a pool while swimming. Following this, the patient reported increased urination and thirst that worsened over the course of 3 years. When she finally had these symptoms evaluated, she was diagnosed with central diabetes insipidus, a disease that is caused by a deficiency in antidiuretic hormone, a hormone released by the pituitary gland [29]. Because the symptoms of diabetes insipidus presented after the concussion, and because the majority of cases of central diabetes insipidus occur following a TBI [30], the authors argue that TBIs may cause hormone deficiencies.<sup>3</sup>

These findings, taken together, suggest that the mild TBIs that routinely occur in contact sports can create pituitary dysfunction and decreased hormone levels. Therefore, hypopituitarism and its related hormone deficiencies might be much more common among athletes in these sports than previously thought. We shall now discuss why exactly TBI-induced hormone deficiency in athletes is cause for concern, and how this concern can be lessened.

<sup>3</sup> Nevertheless, in a recent prospective study Kelly et al. [44] examined the relationship between hormone dysfunction, concussion, and quality of life in retired NFL players. Surprisingly, they did not find that the amount of NFL games played and the number of reported concussions correlated with an increase in hormone dysfunction. Although the exact cause of hormone dysfunction in these players is unknown, the results suggest that hormone dysfunction contributes to poor quality of life. It should be noted, however that there were several notable limitations in this study. For instance, the sample size of NFL players with hormone dysfunction was significantly lower than the same size of NFL players without hormone dysfunction. Additionally, it is notoriously difficult to monitor the concussion history and steroid use history in athletes [44].

## The Effects of Hormone Deficiency and Hormone Replacement Therapy

The two hormones deficiencies that are most frequently related to TBI are GH deficiency and gonadotropin deficiency [31]. This pattern of deficiency following TBI makes sense, because the cells that produce GH and gonadotropins (the somatotrophs and gonadotrophs, respectively) are arguably more vulnerable to damage because of their location in the lateral wings of the pituitary, which only have one blood supply [31]. GH and gonadotropin are hormones that are of great interest in the discussion of performance enhancing drugs, because of the role of GH in building body mass, and the role of the gonadotropins in producing testosterone. Because of their relation to both TBI and performance enhancement, we shall now discuss some of the problems associated with GH and gonadotropin deficiency and the benefits associated with treating these deficiencies with hormone replacement therapy.

### a) Growth hormone

Among the hormone deficiencies that are seen following cases of TBI, GH deficiency is the most common [32]. In a study of 107 patients who had experienced a TBI at least 1 year ago, 40 % were shown to have severe GH deficiency that did not correlate with the severity of their TBI [32]. Although other studies have reported lower rates (7–32 % of TBI cases) [7, 8, 33–35], GH deficiency has been a consistent and robust finding in people who have suffered a TBI.

GH deficiencies are of particular concern because low GH levels have been shown to cause not only physical problems such as fatigue and weakness, but also cognitive and social deficits as well. For example, a meta-analysis showed that GH deficiency is associated with cognitive impairment in several domains, including attention, memory, and executive function [36]. Subjects with GH deficiency also report more social isolation and lower quality of life, suggesting that the disorder may affect their ability to form relationships [32]. Furthermore, TBI patients who go on to develop GH deficiency following the TBI experience symptoms commonly associated with TBI to a greater extent than TBI patients who do not have a GH deficiency. These patients show more severe deficits in attention, memory and executive functioning, and

report lower quality of life and more symptoms of fatigue and depression than TBI patients without GH deficiency [32]. These results suggest that some of the common cognitive and social symptoms associated with TBI may in fact be mediated by GH deficiency caused by the TBI.

Hormone replacement therapy (HRT) has been shown to reverse some of these negative effects of GH deficiency. GH replacement results in significantly greater improvements in attention, memory, and executive function compared to practice alone [36]. GH replacement may also decrease the elevated risk of cardiovascular disease that is found in patients with lower levels of GH, because GH replacement has been shown to improve blood pressure, body weight, inflammation, and blood coagulation [10]. GH replacement also improves depressive and anxious symptoms, reduces hostility, and improves quality of life in patients with GH deficiency [37, 38]. In patients who have GH deficiency following a TBI specifically, GH replacement therapy has been shown to improve performance on cognitive and motor tasks [9, 39]. In a study of two GH-deficient retired boxers with no history of head trauma other than the TBIs received while boxing, GH replacement therapy improved the boxers' body composition, lipid profiles, and quality of life scores [12]. Overall, then, GH replacement therapy appears to have an ameliorative effect on the symptoms associated with GH deficiency. Furthermore, this effect extends to cases of GH deficiency that follow sports-related TBI.<sup>4</sup>

### b) Gonadotropin

Gonadotropin deficiency has also been consistently associated with TBI. Gonadotropin deficiency can cause hypogonadism, a decrease in function of the gonads, which typically results in lessened production of sex hormones such as testosterone. Hypogonadism following decreased gonadotropin levels is especially common in the early period after TBI, with 80 % of patients showing signs of diminished sex steroid levels 12 days following the injury [33]. Long-term hypogonadism following TBI is less common, but has still been reported to occur in 9–17 % of cases, in a period of several months to several years after the TBI [1–3, 6]. Furthermore, the

<sup>4</sup> It is important to emphasize that GH deficiency is a serious problem for both men and women [53] and that both men and women can benefit from GH replacement therapy [54–56].

rate of occurrence of post-TBI hypogonadism does not correlate with the severity of the TBI [33]. The fact that hypogonadism is extremely common in the early period after TBI, combined with the fact that mild TBIs are a relatively frequent occurrence for participants in contact sports suggests these athletes are at a high risk of experiencing hypogonadism.

Similar to GH deficiency, hypogonadism is associated with many negative symptoms, including low muscle mass, muscle weakness, decreased bone mineral density, infertility, and a decreased sense of well-being [40]. The testosterone deficiency that is caused by hypogonadism is associated with many general health issues as well. Testosterone deficiency is associated with fatigue, depressed mood, impaired cognition and memory, and diminished libido, among other things [41]. Increased risk of death from cardiovascular disease has also been linked to hypogonadism that occurs secondary to hypopituitarism [42].

Testosterone replacement therapy (TRT) is commonly recommended as a treatment for hypogonadism [11]. The potential benefits of TRT for men with hypogonadism include increased bone density, increased lean muscle mass, improved cognitive function, elevated mood, and increased physical function [43, 44].<sup>5</sup> Although, to our knowledge, there have been no systematic studies involving treatment of TBI-induced hypogonadism with testosterone replacement therapy, the fact that testosterone replacement is recommended as a treatment for all causes of hypogonadism [45] suggests that it could be used to treat symptoms secondary to TBI.

GH deficiency and hypogonadism both have negative effects on body composition and the ability to tolerate exercise, so these deficiencies may be

of particular concern to athletes. These hormone deficiencies are also associated with many negative long-term consequences, such as diminished cognitive function and increased risk for cardiovascular disease, and so they are of concern for an athlete's general health and well-being as well. The fact that GH deficiency and hypogonadism have both been associated with mild TBIs suggests that many athletes may be suffering these conditions. Because HRT has been shown to treat the negative symptoms associated with hormone deficiency, it is likely that many athletes could benefit from HRT. However, there is a stigma surrounding the use of therapeutic HRT in professional sports, because it is often perceived as a way of circumventing the bans placed on performance enhancing drugs. In the next section, we address some of the concerns about using HRT as a treatment option, and argue, based on the research associating hormone deficiency with mild TBI, that HRT should be viewed as a legitimate treatment option for athletes in sports with high risk of TBIs.

### Hormone Replacement Therapy for Athletes

Generally, the athletic community upholds a distinction between the use of prohibited drugs for therapy and the use of prohibited drugs for performance enhancement [46, 47]. The idea behind the distinction is that taking a banned drug for a therapeutic reason is done in order to treat a disease or to compensate for some deficiency, and so the drug will only bring an athlete up to a normal level of performance. Drug use for performance enhancement, on the other hand, is used to exceed normal levels of performance and gain a competitive advantage. It is often argued that this is an illegitimate reason for taking performance enhancing drugs for a variety of reasons, including reasons of harm, coercion, unnaturalness, and unfair advantage [46, 47]. Although the legitimacy of this distinction can be questioned [48], if we assume, as many do, that there is an important distinction to be made between drug use for therapy and drug use for performance enhancement, then we argue that the recent research on TBIs and hormone deficiency has two major implications for athletic organizations.

First, we argue that the research linking hormone deficiency to TBI suggests that many athletes who

<sup>5</sup> It should be noted that women can suffer with TBI-related hypogonadism [11]. However, in most studies it is either the case that estradiol, rather than testosterone, concentration is used to test for the occurrence of hypogonadism in women [1–3], or that sex steroids are only tested in the men involved in the study [5, 33]. To our knowledge, there is no data linking TBI and low testosterone levels in women, and so TBI-related hypogonadism in women may specifically involve hypoestrogenism. Because of this, and because of the fact that hypogonadism in women is typically treated with a combination of estrogen and progesterone [57], prescribing HRT for female athletes suffering from TBI-related hypogonadism may not run into issues concerning performance enhancement, since estrogen and progesterone are not generally used for this purpose.

participate in sports that bear a high risk of TBI likely could benefit from HRT. Moreover, we argue that the number of athletes who can benefit from HRT is likely to be much higher than is currently acknowledged by the athletic community. As we have discussed above, recent research suggests that mild TBI is related to hypopituitarism, which most commonly manifests as a deficiency in GH and/or gonadotropins. HRT has been shown to alleviate the symptoms of hormone deficiency that are caused by TBI-related hypopituitarism. Because many contact sports have a high rate of mild TBI, it follows that these sports likely carry a high risk for TBI-induced hormone deficiencies. The connection between TBI and hypopituitarism is neither obvious nor well-known and so the neuroendocrine profiles of patients who have suffered a TBI are rarely investigated. The actual rate of hormone deficiency among athletes who participate in contact sports is thus likely to be surprisingly high, especially given the fact that many mild TBIs go unnoticed and unreported by athletes. HRT can treat many of the negative symptoms of hypopituitarism and related hormone deficiency, and therefore many more athletes could benefit from HRT than the athletic community currently acknowledges.

Second, we argue that athletic organizations should prioritize conducting more rigorous and stringent hormone tests, but that the primary purpose of such tests should be evaluating an athlete's health. Hormone testing is currently used primarily to detect when athletes are using prohibited drugs and to discourage athletes from using prohibited drugs in the first place. However, the fact that there is an association between TBIs and hormone deficiency suggests that hormone testing can also serve as a way of screening for TBI occurrences. Mild TBIs often occur without being noticed or reported, and so many athletes who suffer mild TBIs do not get the proper treatment for them. Conversely, the symptoms of hormone deficiency can be subtle and often resemble the symptoms of TBI [19], and so hormone deficiencies can easily go unnoticed if they are not specifically tested for. Recognizing that an individual does in fact have a hormone deficiency is important, because of the widespread negative effects on health such deficiencies can have. More comprehensive and frequent hormone testing could thus be a useful tool for measuring the general health of an athlete, and for determining whether or not an athlete could be in need of further treatment, such as rest, time away from the sport, or HRT. TBIs are of great concern for the athletic

community because of their possible long term effects, and more careful hormone monitoring may be a way of evaluating whether or not TBIs are putting an athlete's health at risk. Furthermore, prioritizing hormone testing can serve as a way of monitoring the use of HRT. Although we argue that HRT may be an important treatment option for athletes, we also acknowledge that offering such treatments comes with the risk of abuse. More stringent hormone testing policies could serve dual purposes of measuring an athlete's overall health and monitoring the appropriate use of HRT.

Of course, this additional testing will likely be expensive, which might give athletic organizations a reason to resist implementing it. However, it is already standard practice that athletic organizations supervise the health of their athletes. Athletes often must pass a certain standard of health and demonstrate that they are fit enough to avoid further injury in order to participate in their respective sport. If, for example, a football player breaks his leg in practice, there are policies which prevent him from returning to play until his leg has healed. The point of these policies is to protect the athlete from further injury, which is in the best interest of both the athlete and the athletic organization that he is competing within. In requesting that athletic organization monitor athletes' hormone levels, we are not asking anything new of athletic organizations. Rather, we are merely asking them to extend their existing policies on athlete health to an aspect of athlete health that has been overlooked and underappreciated.

### **The ARP and the Abuse of Drugs**

Our thesis on extending the use of HRT in athletes stands in strong opposition to the position taken by the Association of Ringside Physicians (ARP), an international organization of physicians that works on improving medicine for athletes participating in boxing and MMA. The ARP has expressed a negative attitude towards the use of HRT in contact sports, and has called for a ban on providing professional fighters with therapeutic use exemptions for TRT in particular [15]. Because we are arguing that HRT could benefit many athletes in boxing and MMA, it is useful to examine the ARP's opposing claim that TRT should be banned from these sports.

The ARP cites three reasons for their position. First, they claim that the need for TRT is "extraordinarily rare" in contact sports and that the use of TRT is "rarely

justified” by contact sports athletes, suggesting that the vast majority of contact sport athletes who use TRT are not using it for legitimate reasons [15]. Second, they hold that all steroid use, whether legitimate or not, “significantly increases” the health risks of contact sports [15]. Third, they maintain that the abuse of performance enhancing drugs creates an unfair advantage and violates the integrity of the sports [15].<sup>6</sup> It is important to note that the ARP is not arguing that there is *in principle* a problem with HRT. Rather, they are arguing that as a *practical* matter few athletes legitimately need it, and because many athletes abuse the current policies that allow athletes to obtain therapeutic use exemptions (TUE) for HRT, it does not make sense to allow such TUEs at all.

We shall not take issue with the ARP’s second and third claim in this paper. We fully acknowledge that any form of HRT bears health risks and that whether it is an appropriate treatment or not will have to be examined on a case by case basis. Additionally, for the purposes of this paper, we grant that the use of HRT for enhancement purposes might violate the integrity of the sport. However, we do think that the claim that the need for TRT is rarely justified should be addressed in light of the research associating brain injury with hormone deficiency. In what follows we shall first establish why the ARP might think that the legitimate need for TRT is rare in contact sports and then we shall explain why we disagree with the ARP’s position.

The ARP does not state why exactly they believe that the legitimate need for TRT in contact sports is “extraordinarily rare”, but we can nevertheless hypothesize why they might hold such a position, given what is currently known about TRT. When it is used therapeutically (i.e. not abused for performance enhancement), TRT is commonly used to treat hypogonadism. In order to determine when the use of TRT to treat hypogonadism in actively competing athletes could be considered “legitimate”, one should consider some of the common causes of hypogonadism:

- (a) Testes (gonads) did not develop properly in pre-adolescence [15].
- (b) Testes were surgically removed or injured due to trauma [15].

<sup>6</sup> It should be noted that it is unlikely that the ARP takes each reason to be independently sufficient for the ban. Rather, it seems that they hold that each reason is necessary to conclude for the ban.

- (c) Aging [15].
- (d) Years of intense training and weight cutting [15].
- (e) Brain injury to pituitary gland [15].
- (f) Prior exogenous anabolic steroid use [15, 49, 50]

The ARP might plausibly argue that (c), (d), (e), and (f) all constitute illegitimate reasons for an actively competing athlete to take TRT. Reason (c), for instance, might be illegitimate because aging is a natural process and thus taking TRT to curb the effects of aging is unnatural, and therefore should not be permitted. Additionally, reason (d) seems to be an illegitimate reason because, even if intense training and dehydration cause an athlete to have low testosterone levels, the ARP might think the treatment should be rest and rehydration rather than TRT. Low testosterone following intense training indicates that an athlete has trained to his limits, and treating such an athlete with TRT would allow him to train more than his competitors not using TRT, thus giving him a competitive advantage. Therefore, TRT used to treat such a condition seems more akin to enhancement than therapy. Moreover, given the fact that simple rest and rehydration can treat the low testosterone levels caused by overtraining, and the fact that HRT has potential dangerous side effects, HRT is not the best treatment option in this instance. Additionally, the ARP might argue that (e) is an illegitimate reason because, insofar as if an athlete has suffered severe enough TBI so that he requires TRT, he is in no condition to continue fighting. Thus, an athlete in this condition might need to be treated with TRT, but should be denied a license to fight due to his current condition of health. Lastly, the ARP might argue that (f) is an illegitimate reason for an actively competing athlete to undergo TRT because the athlete’s current need for TRT stems from a previous violation of policies that prohibited steroid use.

From this, we can generate four general conditions under which the ARP might hold that granting TRT to actively competing athletes suffering with hypogonadism is illegitimate: (1) TRT could allow athletes to train more than is natural.<sup>7</sup> (2) There are alternative treatments, which are safer and more natural. (3)

<sup>7</sup> There are strong reasons to question the legitimacy of a distinction between natural and unnatural treatment. It is notoriously difficult to draw a clear distinction between these terms and even if such a distinction could be made, it is unclear that natural things are always good and unnatural things are always bad. [48]. However, for the purposes of this paper, we shall assume that such a distinction is clear and appropriate.

The athletes are no longer in a healthy condition to fight. (4) The need for TRT is causally related to a previous violation of policy.<sup>8</sup>

On the other hand, the ARP might argue that (a) and (b) constitute legitimate reasons for a TUE for TRT. Notice that unlike (c), (d), (e), and (f), each of these reasons pass the four general criteria set out above. For instance, suppose an athlete suffers from low testosterone levels due to his testes being surgically removed. In such a case, the use of TRT by the athlete does not give him a competitive advantage, because TRT will only return his testosterone to a normal level. Additionally, it is not clear that there are alternative treatments other than some form of TRT. Moreover, the athlete, with the aid of TRT, could very well be in a healthy condition to fight. Lastly, the athlete's low testosterone levels are not causally related to a previous violation of policy.

However, in accordance with the ARP's claims, these legitimate causes of hypogonadism can, in fact, be expected to be rare in elite athletes. For instance, the ARP might argue that (a) is unlikely because individuals suffering hypogonadism due to an untreated problem stemming from pre-adolescence would most likely not acquire the strength and muscle mass to compete at an elite level of athletics. Additionally, the ARP might claim that (b) is rare because it is uncommon for individuals to have their testes surgically removed and damage to the genital region is prohibited in contact sports.

With this in mind, we can formulate why exactly the ARP might think that the legitimate need for TRT is rare in contact sports. They might argue that although (a) and (b) constitute legitimate reasons for receiving TRT, these conditions rarely occur in professional contact sports. Moreover, the ARP might argue that the more common reasons for needing TRT are (d), (e), and (f), however, these are illegitimate reasons for taking TRT.<sup>9</sup>

<sup>8</sup> Note that these conditions are closely related to the four general concerns raised about performance enhancing drugs in sports. They are: (1) unnatural, (2) unfair, (3) coercive, and (4) dangerous. See [46, 47].

<sup>9</sup> (C) is not a common reason for needing TRT because the majority of contact sport athletes tend to be younger, and age-related hypogonadism usually does not begin until mid-forties in men [43]. Thus, if a younger athlete is suffering with low testosterone it is unlikely due to age-related causes. Additionally, it should be noted that the prevalence of age-related low testosterone has likely been overstated by the media [58]. Some researchers attribute the cause of decreased testosterone levels in aging men to other causes, such as illness and weight gain, and do not think that age itself is a significant factor [59, 60].

Therefore, because so few athletes legitimately require TRT, and so many seek to use it illegitimately, it makes sense to ban TRT altogether.

Now that the ARP's position has been established, we will show why we disagree with it. We deny that (e) and (f) are illegitimate reasons for active athletes to be granted at TUE for TRT through a TUE. Moreover, we argue that this suggests that it is not rare for contact sports athletes to require TUEs for TRT.

As explained above, the ARP might argue that (e) is an illegitimate reason to take TRT because athletes suffering severe enough head trauma to require TRT should not be licensed to fight. However, the evidence suggests that TBIs, regardless of severity, can lead to hormone deficiency at fairly high rates. Since contact sports bear a high risk of mild TBI, it is thus not unlikely that athletes participating in these sports would suffer from TBI-related hypogonadism. In other words, it does not require a severe, or even a moderate TBI to cause hypogonadism. Now, we can still ask a further question about whether or not athletes who have suffered mild TBIs should be allowed to compete, especially given the evidence that mild TBIs can contribute to neuroendocrine dysfunction. We fully acknowledge that the dangers of mild TBIs have been significantly underappreciated. However, if we prohibit athletes who have experienced mild TBIs from competing, then sports such as boxing and mixed martial arts would likely be unable to continue in their current form, because the athletes that train and compete in them routinely experience mild TBIs. Perhaps this is the right move for society to make. Nevertheless, our opponent, the ARP, is unlikely to think these sports should be discontinued or drastically changed. Therefore, if we are willing to accept the risk of head trauma associated with contact sports, then the athletes competing in these sports should be granted TUEs for TRT and other forms of hormone replacement therapy to treat TBI related neuroendocrine dysfunction.<sup>10</sup>

Lastly, let us turn our attention to the claim that hypogonadism caused by previous steroid use is an illegitimate reason for TRT. One might argue that this is not a legitimate use of therapeutic TRT, because the cause of the athlete's hypogonadism stems from a past

<sup>10</sup> Additionally, it should be noted that in many contact sports, including boxing and MMA, athletes are allowed to treat tendon injury with steroid or analgesic injections—even though these treatments can be performance enhancing. This raises further questions about why the ARP is specifically prohibiting HRT and not these other treatments as well.



violation of the rules. However, in many cases in which athletes participating in contact sports suffer with hypogonadism, there will be an overdetermination of causes for this condition. Consider the following example. Tom competes in mixed martial arts, he has had 25 professional fights and has sparred countless hours in the gym. Previously, Tom has been caught taking steroids, as a result of this he was fined and suspended a year by the athletic commission. Years later, Tom's testosterone levels are low compared to normal levels. Given Tom's background, a number of things could have plausibly caused his low testosterone levels. However, given what we know about low testosterone in competitive athletes, three potential causes stick out in particular: rigorous training and dehydration, mild TBIs, and previous steroid use. If Tom's levels remain low after resting and hydrating, we can rule out that overtraining and dehydration are the cause. This leaves either mild TBIs or his previous steroid use as the likely cause of his hypogonadism. It is unclear, however, how exactly we can leap the epistemic hurdle that is determining which of these is the precise cause of Tom's low testosterone levels. Mild TBI received while competing in the sport could very well be the cause of his hypogonadism, and it would be hard to conclusively rule this out in favor of previous steroid use as the cause. If we cannot say with a high-degree of confidence that it is Tom's previous violation of the ban on steroids, rather than the TBIs he received, that resulted in his hypogonadism, then it seems unjust not to grant Tom a TUE for TRT. Tom's condition could easily be the result of an injury he received while competing in the sport and so he should not be denied treatment for it simply because his condition may have also been caused by prior steroid use.<sup>11</sup>

When the research on the association between mild TBIs and hormone deficiency is taken into account, HRT becomes a legitimate treatment option for competing athletes. Mild TBIs frequently occur in contact sports, and so the need for HRT can be expected to be

common, given this research. Denying athletes therapeutic use of HRT would thus be detrimental to the health of the athletes, since HRT can be used to treat a condition that associated with a common kind of injury caused by competing in the sport.

## Conclusion

In this paper, we examined the research on sports-related TBIs, neuroendocrine dysfunction, and HRT. We argued that the evidence suggests that it is likely many more athletes than previously thought suffer with neuroendocrine dysfunction and hence could benefit from HRT. Additionally, we argued that athlete hormone levels should be tested more rigorously and frequently with an emphasis on monitoring for TBI and TBI-related issue rather than as a means only for detecting policy violation. Of course, much more research needs to be done on the relationship between sports related TBIs, neuroendocrine dysfunction, and HRT. Systematic study of hypopituitarism in athletes training and competing in sports with high rates of TBIs is required in order to determine just how prevalent the problem is in athletes specifically. Furthermore, if hypopituitarism is, in fact, a widespread problem for athletes competing in contact sports, then systematic study of the effects of HRT on this population specifically is also required.

As discussed above, the symptoms of hypopituitarism can be subtle and can easily go unnoticed by competing athletes and their physicians. However, hypopituitarism can negatively affect an athlete's performance, and can have widespread and lifelong consequences. Therefore, the possible benefits of HRT in athletes at risk for TBI-induced hypopituitarism should be seriously considered. TBI incidence in contact sports is, by itself, a health concern for the athletes involved. Athletic organizations should not further put their athletes' health at risk by denying the legitimacy of HRT for competing athletes, when HRT can potentially be a treatment for the hormone deficiencies that appear to be a relatively common consequence of TBIs experienced in the sport. Despite the fact that TBI-induced hypopituitarism is a relatively new area of research, the current findings suggest that this will be an area of research that can and should impact sports medicine and policy. If nothing else, we hope this paper highlights the importance of recognizing the association between sports

<sup>11</sup> Note that one might argue that if it could be shown that the probable cause of Tom's low testosterone levels was steroids, then it would be justifiable to deny him a TUE for TRT. Although we do think there are ways to counter these arguments so that it ends up being justifiable for Tom to receive a TUE regardless of his past history, we will not discuss this issue here because it concerns the legitimacy of performance enhancement in sports more generally, rather than the legitimacy of using performance enhancing drugs from treating TBI-related conditions.

related TBI and hormone deficiency, and encourages further research on this issue.

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