

# Attention Deficit Hyperactivity Disorder: Unique Considerations in Athletes

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**Context:** Attention deficit hyperactivity disorder (ADHD) is a common psychiatric condition in the general population, with evidence suggesting that it may be more common among athletes.

**Evidence Acquisition:** Literature searches were performed on PubMed, MEDLINE, and Cochrane databases for the years 2000 to 2016 utilizing the following key search terms: *ADHD, ADD, guidelines, diagnosis, athlete, sports, treatment, pharmacotherapy, stimulants, risk, cardiovascular effects, concussion, and traumatic brain injury (TBI)*.

**Study Design:** Clinical review.

**Level of Evidence:** Level 4.

**Results:** ADHD exists among athletes at all levels of play, and symptomatology overlaps significantly with that of concussion. Treatment with stimulants has cardiovascular effects and may not be permitted by the athlete's governing body. An athlete's level of competition and individual cardiovascular risk factors may therefore affect medication choices.

**Conclusion:** ADHD diagnosis and treatment are paramount to optimal quality of life and functioning in affected individuals. Pharmacologic treatment options should not specifically be avoided in athletes; however, stimulant use is an independent risk factor for heat illness. Concussion, a common athletic injury, may have an altered course in those affected by ADHD, specifically with regard to neurocognitive testing and recovery.

**Keywords:** ADHD; athletes; NCAA; concussion; pharmacologic treatment

Overall, there are limited data on mental disorders in athletes, and there is even less available research on the use of psychiatric medications in athletes. There continues to be an improper assumption that mental disorders in athletes are relatively uncommon compared with the general population.<sup>38</sup> The reason for this includes athletic idealization, the tendency of athletes to minimize symptoms, and the overlap of symptoms of overtraining with depression.<sup>38</sup> Attention deficit hyperactivity disorder (ADHD) is included in this relative paucity of athlete-specific research, with most information being extrapolated from general ADHD literature. Specific information exists regarding the impact of the disease on sports-related injuries (eg, concussion) and the physiologic effects of treatment with stimulant medications.

## ADHD: AN INTRODUCTION TO DIAGNOSIS AND SOCIETAL IMPACT

ADHD is a primarily heritable neurodevelopmental disorder, with growing evidence of the genetic components altering the synthesis, presynaptic release and reuptake, and postsynaptic reuptake of catecholamines in different regions and networks in these individual's brains.<sup>22,23,34</sup> It is characterized by behavioral problems with hyperactivity, impulsivity, and/or inattention, which cause persistent impairment in most areas of life and cannot be better explained by another mental disorder.<sup>34</sup> The American Academy of Pediatrics (AAP) recommends using *Diagnostic and Standard Manual of Mental Disorders* (DSM) criteria to ensure consistent diagnostic accuracy in these

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patients.<sup>42</sup> With regard to DSM diagnostic criteria, a major change occurred between *DSM-IV* and *DSM-5* with regard to age of onset, now allowing for symptoms to present prior to 12 years instead of 7.<sup>42</sup> A formal diagnosis occurs through history alone, with utilization of standardized symptomatology questionnaires, as there is no standardized objective measure. The importance of screening for comorbidities and performing a physical examination is universally recognized among national and international guidelines for ADHD, as they aid in ruling out alternative medical causes (eg, hearing impairment) and ensuring safety of pharmacologic therapy.<sup>41</sup>

The diagnosis of ADHD remains an important one due to the increased risk these individuals have for comorbid psychiatric conditions and its overall impact on function. Individuals with ADHD have increased rates of depression, anxiety disorders, bipolar disorder, oppositional defiant and conduct disorders, as well as learning and language developmental disorders.<sup>16,34,37,42,45</sup> Also notable, they have twice the lifetime risk of substance abuse compared with the general population and a 2-fold increased risk of cigarette smoking beginning in their adolescent years compared with their non-ADHD peers.<sup>16,34,42,45</sup> Additionally, when untreated, they have greater rates of motor vehicle accidents, speeding tickets, and divorce and lower rates of self-esteem, educational attainment, employment, and household income.<sup>37,42,45</sup>

## ADHD AND THE ATHLETE

ADHD incidence in the general school-age population approaches 3% to 10%, with evidence suggesting that this percentage may be higher among athletes.<sup>6,17,34,37,42</sup> The main explanation for this is the positive influence that athletic participation appears to have on individuals with ADHD.<sup>22,30</sup> Athletic participation can serve as a reliable emotional and physical outlet for coping with symptoms.<sup>17,30,34</sup> Athletic involvement also tends to be an environment to experience positive reinforcement, and individuals with ADHD sometimes naturally excel in their sports (because of their inherent impulsivity placing them at a natural advantage for making quick and reactionary decisions).<sup>17,34</sup> This is in contrast to academic settings, which can be a source of stress and trouble, creating an environment where individuals with ADHD may often be less successful.

There has been speculation and concern regarding the diagnosis of ADHD occurring after an athlete enters a collegiate environment. The diagnosis requires persistent symptomatology early in life, and many feel that this particular psychiatric disorder, in contrast to most others, does not persist into adulthood. ADHD is by definition a spectrum disorder that has varying degrees of hyperactivity and inattention behaviors. Individuals with ADHD who primarily have hyperactivity symptoms are identified earlier in childhood, often due to disruptive behavior in the classroom environment. Individuals with primarily inattention symptoms, however, may go unnoticed for much longer.<sup>6,34</sup> Only once the academic

demands become too great for the individual and there is a loss of the previous outside regulation provided by parental presence (as is often the case in the collegiate setting) do some patients present with overt symptomatology.<sup>6,34</sup>

Adolescents and adults with ADHD are less likely to exhibit overt hyperactivity, which may be a confounding variable for delayed diagnosis in the athletic collegiate population.<sup>23,34,42</sup> Some argue that given the frequent comorbid conditions that exist with ADHD, the issues that arise from the comorbid condition frequently override those of ADHD as individuals approach adulthood, thereby allowing ADHD to be overlooked.<sup>16</sup> With growing evidence that ADHD should no longer be simply thought of as a problem of childhood and adolescence because it can persist into adulthood, a diagnosis can indeed be made later in life.<sup>14,23,41</sup> Health care providers should be aware and sensitive to the possibility of a delayed ADHD diagnosis in collegiate athletes.

The concern regarding physiological and potential psychological effects of stimulant medication use in athletes is a unique one. There are some specific physiological effects of stimulant medications that warrant awareness within and particular attention to the athletic population consuming them.

## TREATMENT

Given the clear social, functional, and societal impact that ADHD has on an affected individual, treatment options remain an important piece in care and management. Effective treatment not only improves quality of life and academic performance, but has also demonstrated a decrease in the rate of substance abuse, driving errors, and the prevalence of comorbid psychological disorders.<sup>4,35</sup> Additionally, given the previously described high rate of comorbid conditions, tailoring treatment to additionally address these issues cannot be overlooked.

Treatment of ADHD generally falls into 2 large divisions: behavioral/psychosocial interventions and medications. There is a general consensus that treatment should focus on psychosocial interventions with or without medication.<sup>37,41,42</sup> The specifics of behavioral interventions are not outlined but encompass behavior therapy, cognitive behavioral therapy, individual education plans, parent teaching/training, caregiver support, and education on the condition for the patient, family, and coaches.<sup>41,42</sup> Through behavioral therapy, a psychologist can help a patient establish consistent patterned behaviors and a more structured lifestyle and environment. There are data demonstrating the positive benefits of physical exercise in helping children manage their ADHD, making an argument that it could and/or should be included as part of a comprehensive treatment plan.<sup>22,30</sup>

Medications have become the mainstay for treatment in recent years unless the impairment is mild or they are declined by the patient or parent/guardian.<sup>24</sup> Pharmacologic treatment for ADHD can be broken down into 2 large categories: stimulant and nonstimulant medications. Both groups of medication have

Table 1. ADHD pharmacologic treatment options<sup>24,28,34,35</sup>

Stimulant Medications				
Drug	Duration of Action, h	FDA-Approved for ADHD	NCAA Exemption Needed	WADA/IOC Banned
Methylphenidate <i>Ritalin/Methylin</i>	3-12	Yes	Yes	Yes
Dextroamphetamine and amphetamine <i>Adderall</i>	6-10	Yes	Yes	Yes
Dextroamphetamine <i>Dexedrine/Dexrostat</i>	4-8	Yes	Yes	Yes
Lisdexamfetamine <i>Vyvanse</i>	8-12	Yes	Yes	Yes
Modafinil <i>Provigil</i>	10-12	No	Yes	Yes
Armodafinil <i>Nuvigil</i>	12-15	No	Yes	Yes
Nonstimulant Medications				
Drug	Class	FDA-Approved for ADHD	NCAA Exemption Needed	WADA/IOC Banned
Atomoxetine <i>Strattera</i>	SNRI	Yes	No	No
Bupropion <i>Wellbutrin</i>	SSRI	No	No	No
Imipramine <i>Tofranil</i>	TCA	No	No	No
Nortriptyline/amitriptyline <i>Pamelor/Elavil</i>	TCA	No	No	No
Desipramine <i>Norpramin</i>	TCA	No	No	No
Clonidine <i>Catapres/Kapvay</i>	Alpha-2 adrenergic	No	No	No
Guanfacine <i>Intuniv/Tenex</i>	Alpha-2 adrenergic	No	No	No

ADHD, attention deficit hyperactivity disorder; FDA, US Food and Drug Administration; IOC, International Olympic Committee; NCAA, National College Athletic Association; SNRI, serotonin and norepinephrine reuptake inhibitors; SSRI, selective serotonin reuptake inhibitors; TCA, tricyclic antidepressants; WADA, World Anti-Doping Agency.

advantages and disadvantages that need to be considered when deciding on treatment (Table 1).<sup>24,28,34,35</sup>

Stimulant medications remain the first-line medical therapy among national and international ADHD guidelines and are the most effective.<sup>24,36,41</sup> The AAP and American Association of Child and Adolescent Psychiatry (AACAP) clearly express their

support for use of stimulant medications with continual monitoring.<sup>41,42</sup> These medications act on the neurotransmitters by blocking the reuptake of dopamine and norepinephrine, which is responsible for increasing attention span and concentration.<sup>34,36</sup> Stimulants have a rapid onset, typically within 1 hour, with various durations of action. Individual treatment

Table 2. NCAA regulations for athletes with ADHD<sup>34,35</sup>

NCAA Policy—ADHD Key Points
<ul style="list-style-type: none"> <li>• Evidence that the student athlete has undergone clinical assessment to diagnose the disorder</li> <li>• If the diagnosis of ADHD was made in childhood, the student athlete has to provide a copy of the comprehensive assessment. If these documents are not available, then a comprehensive assessment must be performed</li> <li>• Therapeutic use exemption is mandatory documentation</li> <li>• Routine monitoring when using psychostimulant medication</li> <li>• Annual clinical evaluation by the team physician</li> <li>• Current prescription must be maintained on file</li> <li>• Mandatory reporting of any known history of substance abuse</li> </ul>

ADHD, attention deficit hyperactivity disorder; NCAA, National College Athletic Association.

regimens can be customized through the use of short-, moderate, or long-acting formulations. Common side effects include gastrointestinal upset, decreased appetite, headache, insomnia, and increased heart rate and blood pressure.<sup>7,24,34,36</sup> There is additional concern for cardiovascular side effects, including sudden cardiac death (SCD).

Several nonstimulant medications have been used to treat ADHD, but only 1 is approved by the US Food and Drug Administration (FDA): atomoxetine. All nonstimulant medications have a 24-hour duration of action, with the first 12 hours as the most beneficial. Unfortunately, the therapeutic benefit is not appreciated until 3 to 6 weeks of use.<sup>34</sup> The major benefit to these medications is the absence of both psychological and physiologic abuse concerns; however, side effect profiles of certain classes like tricyclic antidepressants (TCAs) often deter their usage in competitive athletes.<sup>37</sup>

### Athlete- and Sport-Specific Medical Treatment Considerations

When considering treatments for ADHD, level of involvement in athletics can help dictate medication choices. Many sports leagues and organizations around the world follow the guidelines established by the World Anti-Doping Agency (WADA).<sup>24</sup> Stimulant medications are listed on the WADA banned substance list and therefore have been banned by the International Olympic Committee (IOC) because of their ergogenic potential.<sup>37</sup> For athletes participating in college sports under the supervision of the National College Athletic Association (NCAA), stimulants require a therapeutic use exemption (TUE) to be permitted. The NCAA created a policy in 2009 with regulations for student athletes with ADHD (Table 2).<sup>34,35</sup> Additionally, professional sports organizations, including Major League Baseball and the National Football League, have developed their own specific regulations for TUEs.<sup>26,32</sup>

The designated sport and position are also factors that need to be considered in the overall treatment decisions for an athlete with ADHD. Some athletes perform better while taking ADHD medications, for example, a baseball catcher, experiencing

improved focus and concentration. In comparison, a basketball point guard or wrestler may benefit from the spontaneity and unpredictability when untreated.<sup>7,38</sup> All athletes, however, tend to benefit when medications are used for practices as they aid with coaching and instruction. Taking all these factors into consideration, a strategy that can be employed is timing medication intake such that it is maximally effective during times of need (eg, academic sessions or certain athletic events) and less effective during specific athletic competition where their relative symptomatology is advantageous.<sup>7</sup>

A physician who is responsible for athletes with ADHD needs to carefully consider all options when choosing treatments. There needs to be open communication with the athlete as well as consultants when necessary. The primary goal is to design regimens to achieve success and meet athletic goals while remaining compliant with established policies.

### Stimulant Abuse Concerns

Much concern exists in the general public regarding the risk of abuse of stimulant medications. The concerns of ergogenic abuse and unfair advantages have resulted in banning and TUEs in the athletic arena. The uneasiness and apprehension regarding prescribing medication that can be misused for intoxication purposes is an additional issue. The hypothesis that treating ADHD with stimulants will contribute to substance abuse has largely been discounted, with the argument instead leaning toward treatment to reduce the downstream risk of substance abuse.<sup>11,34,37,42,46</sup> The American Medical Society for Sports Medicine (AMSSM), while recognizing the potential risk of abuse of stimulant medications, clearly states in its 2011 position statement that this fear alone does not justify withholding pharmacologic treatment.<sup>37</sup>

## CARDIOVASCULAR EFFECTS OF STIMULANTS

Stimulants have effects on the cardiovascular system. Heart rate and blood pressure effects have been studied and demonstrated.<sup>36,37</sup> An average increase of 1 to 2 beats per

minute in resting and exertional heart rates occurs in patients taking stimulants such as methylphenidate and amphetamines, with 1 study demonstrating an increase in heart rate of 11 beats per minute in methylphenidate-naive patients.<sup>36,37</sup> Similar effects have been seen in other ADHD medications, such as atomoxetine and modafinil. A 3- to 4-mm Hg increase in systolic and diastolic blood pressure has also been shown with these medications.<sup>36,37</sup> The clinical significance of these physiologic findings is undetermined, but most likely inconsequential.<sup>36</sup>

The larger concern for athletes taking stimulant medications is the risk for SCD. SCD is a rare but highly publicized cause of death in the athletic population and has been reported in athletes taking stimulants.<sup>7,24,34,35</sup> SCD occurs as a result of underlying cardiac disease such as hypertrophic cardiomyopathy, long QT, Brugada syndrome, arrhythmogenic right ventricular dysplasia, and Wolff-Parkinson-White syndrome. These conditions lead to uncontrolled ventricular arrhythmias that occur with exertion and can lead to death if defibrillation is not performed in a timely fashion.

Screening electrocardiogram (ECG) protocols to identify athletes with cardiovascular disease, which places them at risk for SCD, have been initiated in other countries, including Japan and Italy.<sup>9,10,44</sup> However, the cost-effectiveness and potential for harm has prevented the adoption of universal athletic screening in the United States.<sup>36</sup> Conditions that predispose to SCD have an incidence of 0.3% in the United States, and there is little evidence that young athletes are at greater risk for SCD than the general population of their peers.<sup>12</sup> Additionally, ECG interpretation has poor interexaminer reliability, even among experts, and false-positives lead to further unnecessary testing, incurring additional costs, resources, and risk to the patient.<sup>12</sup> Stimulants, unlike TCAs, for example (which are known to cause ECG alterations of QT prolongation, atrioventricular block, and ventricular arrhythmias), have not been shown to cause ECG alterations that would put an individual at risk of SCD.<sup>36,37</sup>

Stimulants do not specifically increase SCD risk in healthy athletes without known heart disease.<sup>36</sup> The rate of SCD has been shown to be lower in those taking stimulants compared with those not taking stimulants. One 2006 study found that 2 cases of SCD occurred per 1 million athletes taking stimulants, compared with between 8 and 62 cases of SCD per 1 million athletes not taking stimulants.<sup>46</sup> A 2011 retrospective cohort study also found that stimulant use was not associated with increased risk of serious cardiovascular events (including SCD, stroke, and myocardial infarction) in children and young adults.<sup>8</sup>

Despite a lack of evidence to suggest that stimulant use increases SCD risk, the American Heart Association made a statement in 2008 recommending routine screening ECGs in children prior to initiating stimulant use.<sup>44</sup> Medical academies, including the AAP and AACAP, responded with a counterstatement that recommends against routine screening ECGs prior to initiating stimulants.<sup>37</sup> The AMSSM agreed with this counter-recommendation in its 2011 position statement on ADHD and the athlete, specifically stating ECG screening is only recommended in athletes with the following clinical scenarios:

concerning findings on history/physical examination prior to initiating stimulant therapy, family history of predisposing conditions, and medical treatment incorporating use of TCAs.<sup>37</sup>

Stimulants for ADHD are known to cause subtle changes in heart rate and blood pressure; however, there is little to no evidence to suggest increased risk of SCD. It is generally recommended that stimulants not be withheld in otherwise healthy athletes with ADHD due to concern for cardiovascular effects and SCD. History and physical examination should guide the necessity to evaluate an athlete's cardiovascular status further with ECG screening. If an athlete has a risk factor for cardiovascular disease or has known cardiovascular disease, stimulants should be avoided.

## HEAT ILLNESS AND STIMULANTS

Heat illness is a serious cause of mortality among the young athlete, ranking as the third most common cause of death in athletes, accounting for about 9000 cases annually.<sup>19,21</sup> Heat illness is defined as the body's inability to regulate and offset the increase in core body temperature associated with exertion.<sup>1,19</sup> Exertional heat exhaustion and stroke occur as a result of a combination of factors, including dehydration, sodium loss through sweating, and energy depletion. When blood temperatures increase by less than 1°C, the peripheral and central heat receptors are activated to initiate thermoregulation.

Cooling mechanisms include cutaneous vasodilation, sweating, tachycardia, and increased minute ventilation. At elevated temperatures, it can be difficult for normal thermoregulatory mechanisms to keep up with increasing core body temperatures during exertion. Effective cooling relies on adequate cardiac output, which can be compromised at elevated body temperatures. Specifically, physiologic responses to exertion at elevated temperatures, such as dehydration and electrolyte abnormalities, result in decreased cardiac output.<sup>5</sup>

The risk of developing heat illness increases for athletes on stimulants because of their effects on the body's regulatory system.<sup>28,39</sup> Stimulants directly interfere with normal thermoregulation by altering neurotransmitter activity in the brain.<sup>28</sup> Medications such as methylphenidate and amphetamine salts work primarily by increasing extracellular dopamine and norepinephrine concentrations in the brain as well as limiting the synthesis of serotonin.<sup>28,31</sup> These neurotransmitter alterations either directly or indirectly contribute to acquiring higher core temperatures when exercising in warm environments as well as altering one's perception of fatigue and exertion.<sup>28,39</sup>

Hyperthermia causes reduced muscle activity and increases an athlete's perception of exertion, perhaps as a preservation mechanism to decrease exertion and lower the core body temperature.<sup>39</sup> Methylphenidate specifically dampens the athlete's perception of exertion, allowing them to continue to exercise despite elevating core body temperatures and dehydration.<sup>39</sup> In general, 75% of exercisers in 1 study fatigued at rectal temperatures of 39.1°C.<sup>40</sup> After the administration of

methylphenidate, however, these athletes had higher core body temperatures (40°C) when exercising in warm environments compared with ambient temperatures (18°C).<sup>39</sup> Cyclists were able to cycle faster and 32% longer at higher levels of cardiorespiratory and metabolic stress after administration of methylphenidate compared with peers taking placebo.<sup>39,43</sup>

Stimulants can override the body's normal thermoregulatory mechanisms through a dangerous combination of increased exercise tolerance in elevated temperatures, decreasing perception of exertion, and elevated core body temperatures. Clinicians should be aware of these effects on thermoregulation when prescribing stimulants to athletes, especially those who participate in activities requiring sustained cardiovascular exertion.

## CONCUSSION AND ADHD

There are an estimated 1.6 to 3.8 million concussions per year, with approximately 9% occurring during sport-related activities.<sup>2,18,25,27,29</sup> Of these, the majority appear to occur in children and adolescents.<sup>15</sup> The approach to concussion diagnosis and management remains at the forefront of sports medicine pathology and continues to evolve through ongoing research. A focus of this continued investigation is the recognition of risk factors and modifiers that influence the clinical course and management of concussions. Several societies and consensus statements identify neuropsychiatric disorders, including ADHD, as an important modifier in concussion.<sup>1,3,18,25,29,47</sup>

Both ADHD and concussion involve and intersect several neurocognitive domains, including memory, attention, and concentration.<sup>18,47</sup> Therefore, ADHD is a variable that directly influences several areas of concussion evaluation, including the clinical presentation, physical examination, diagnostic neurocognitive testing, and recovery.<sup>18,29</sup> In 1 study comparing data from 8056 high school and collegiate athletes, individuals with ADHD had a greater rate of baseline fatigue, difficulty concentrating, trouble sleeping, difficulty remembering, and balance problems—all of which can be seen in the presence of concussion.<sup>33</sup>

Differences with executive functioning, processing speed, and reaction time on neurocognitive pre- and postconcussion testing have been found to be lower overall among individuals with ADHD when compared with standard normative data.<sup>13,20,27,47</sup> The combined effects of ADHD and learning disability (LD), a common comorbid developmental disorder, can also have significant influence on baseline neurocognitive performance.<sup>13,33,47</sup> Significantly lower scores in verbal, visual, memory, processing speed, and reaction time have been found on baseline testing in individuals with these combined developmental disorders.<sup>13</sup> Compared with their non-ADHD peers, individuals with ADHD can also show a continued decline in repeat neurocognitive testing scores after concussion. This may be due to worsening inattention from ADHD rather than from concussion.<sup>11,13</sup> All of these factors make evaluation and management of concussion more complex in this patient population.

There is also thought that concussions in the presence of ADHD have an altered recovery trajectory, with a slower recovery of up to 3 days.<sup>3,20,27</sup> Although recovery can be prolonged, there does not appear to be a risk of developing chronic or worsened ADHD symptoms after concussion. An anticipated longer mean recovery time can be clinically relevant when determining management, return to learn, and return to play. There is no evidence that the treatment of concussion with stimulants is effective in the overall recovery or time to return to play. If an individual with ADHD is well controlled on stimulants at the time of injury, however, it is recommended that the medication be continued.<sup>18</sup>

It is important to maintain awareness of ADHD as a risk modifier and prognostic marker when approaching an individual with a concussion.<sup>3</sup> To optimize management, it is recommended to identify athletes with the diagnosis of ADHD, either through a thorough history or preparticipation physical.<sup>29</sup> Since individuals with ADHD often have baseline concussion symptoms and lower baseline performance on neurocognitive testing, pretesting and baseline evaluation is beneficial in this population.<sup>13,18,33,47</sup> Also, with the known differences in ADHD and concussion presentation and testing, there is consideration to develop standard normative data for individuals with these combined diagnoses.<sup>13,33,47</sup>

## CONCLUSION

ADHD is a common and arguably underrecognized heritable neurodevelopmental psychiatric disorder. It affects both athletes and nonathletes, with sports participation being a mutually beneficial environment whereby these individuals can naturally excel as well as have an outlet for symptom management. Diagnosis requires awareness and utilization of standardized symptomatology questionnaires. Treatment for ADHD in athletes is imperative, not only for quality of life and academic success but also to reduce their increased risk of many comorbid psychiatric conditions, including but not limited to substance abuse.

Stimulant medications remain a mainstay of successful treatment in the ADHD population, and athletic participation should not preclude this as a medical intervention unless their athletic governing body specifically bans it. Team physicians, depending on their team's level of competition, may need to be aware of both the national and international regulations regarding stimulant medication use.

Regardless of level of play, team physicians must be aware of the increased risk of heat illness due to the physiologic effects of stimulants. When considering stimulant medication initiation, a thorough cardiovascular history and examination is warranted; however, stimulants do not specifically cause ECG changes or SCD, and routine ECG screening is not appropriate in this population.

Finally, ADHD affects both concussion diagnosis and recovery as it affects both symptomatology and neurocognitive testing domains, requiring investigation as part of past medical history when athletes present for concussion diagnosis and management.

## REFERENCES

1. Alosco ML, Fedor AF, Gunstad J. Attention deficit hyperactivity disorder as a risk factor for concussions in NCAA division-I athletes. *Brain Inj*. 2014;28:472-474.
2. Alosco ML, Knecht K, Glickman E, Gunstad J. History of concussion and exertional heat illness symptoms among college athletes. *Int J Athl Ther Train*. 2012;17:22-27.
3. Biederman J, Feinberg L, Chan J, et al. Mild traumatic brain injury and attention-deficit hyperactivity disorder in young student athletes. *J Nerv Ment Dis*. 2015;203:813-819.
4. Biederman J, Monuteaux MC, Spencer T, Wilens TE, Faraone SV. Do stimulants protect against psychiatric disorders in youth with ADHD? 10-year follow-up study. *Pediatrics*. 2009;124:71-78.
5. Bouchama A, Knochel JP. Heat stroke. *N Engl J Med*. 2002;346:1978-1988.
6. Broshek D, Freeman JR. Psychiatric and neuropsychological issues in sport medicine. *Clin Sports Med*. 2005;24:663-679.
7. Conant-Noville DO, Tofler IR. Attention deficit/hyperactivity disorder and psychopharmacologic treatments in the athlete. *Clin Sports Med*. 2005;24:829-843.
8. Cooper WO, Habel LA, Sox CM, et al. ADHD drugs and serious cardiovascular events in children and young adults. *N Engl J Med*. 2011;365:1896-1904.
9. Corrado D, Basso C, Pavei A, Michieli P, Schiavon M, Thiene G. Trends in sudden cardiovascular death in young competitive athletes after implementation of a preparticipation screening program. *JAMA*. 2006;296:1593-1601.
10. Corrado D, Basso C, Schiavon M, Thiene G. Screening for hypertrophic cardiomyopathy in young athletes. *New Engl J Med*. 1998;339:364-369.
11. Cottle JE, Hall EE, Patel K, Barnes KP, Ketcham CJ. Concussion baseline testing: preexisting factors, symptoms, and neurocognitive performance. *J Athl Train*. 2017;52:77-81.
12. Drezner JA, O'Connor FG, Harmon KG, et al. AMSSM position statement on cardiovascular preparticipation screening in athletes: current evidence, knowledge gaps, recommendations, and future directions. *Clin J Sport Med*. 2016;26:347-361.
13. Elbin R, Kontos A, Kegel N, Johnson E, Burkhart S, Schatz P. Individual and combined effects of LD and ADHD on computerized neurocognitive concussion test performance: evidence for separate norms. *Arch Clin Neuropsychol*. 2013;28:476-484.
14. Faraone SV, Biederman J, Mick E. The age-dependent decline of attention deficit hyperactivity disorder: a meta-analysis of follow-up studies. *Psychol Med*. 2006;36:159-165.
15. Gessel LM, Fields SK, Collins CL, Dick RW, Comstock D. Concussions among United States high school and collegiate athletes. *J Athl Train*. 2007;42:495-503.
16. Gillberg C, Gillberg IC, Rasmussen P, et al. Co-existing disorders in ADHD—implications for diagnosis and intervention. *Eur Child Adolesc Psychiatry*. 2004;13(suppl 1):180-192.
17. Gökçen C, Abakay U, Ünal A, et al. Is there any relationship between ADHD symptoms and choosing sports education at the university? *Int J Psychiatry Med*. 2013;46:169-178.
18. Harmon KG, Drezner JA, Gammons M, et al. American Medical Society for Sports Medicine position statement: concussion in sport. *Br J Sports Med*. 2013;47:15-26.
19. Howe AS, Boden BP. Heat-related illness in athletes. *Am J Sports Med*. 2007;35:1384-1395.
20. Iverson GL, Lowell MR, Collins MW. Validity of ImPACT for measuring processing speed following sports-related concussion. *J Clin Exp Neuropsychol*. 2005;27:683-689.
21. Kerr ZY, Casa DJ, Marshall SW, Comstock RD. Epidemiology of exertional heat illness among U.S. high school athletes. *Am J Prev Med*. 2013;44:8-14.
22. Kiluk BD, Weden S, Culotta VP. Sport participation and anxiety in children with ADHD. *J Atten Disord*. 2009;12:499-506.
23. Konrad K, Eickhoff SB. Is the ADHD brain wired differently? A review on structural and functional connectivity in attention deficit hyperactivity disorder. *Hum Brain Mapp*. 2010;31:904-916.
24. Kutcher JS. Treatment of attention-deficit hyperactivity disorder in athletes. *Curr Sports Med Rep*. 2011;10:32-36.
25. Langlois JA, Rutland-Brown W, Wald MM. The epidemiology and impact of traumatic brain injury: a brief overview. *J Head Trauma Rehabil*. 2006;21:375-378.
26. Major League Baseball's Joint Drug Prevention and Treatment Program. <http://mlb.mlb.com/pa/pdf/jda.pdf>. Accessed January 1, 2017.
27. Mautner K, Sussman WI, Axtman M, Al-Farsi Y, Al-Adawi S. Relationship of attention deficit hyperactivity disorder and postconcussion recovery in youth athletes. *Clin J Sport Med*. 2015;25:355-360.
28. May DE, Kratochvil. Attention-deficit hyperactivity disorder recent advances in paediatric pharmacotherapy. *Drugs*. 2010;70:15-40.
29. McCrory P, Meeuwisse WH, Aubry M, et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012. *Br J Sports Med*. 2013;47:250-258.
30. McKune AJ, Pautz J, Lombard J. Behavioural response to exercise in children with attention-deficit/hyperactivity disorder. *S Afr J Sports Med*. 2003;15(3):17-21.
31. Meeusen R, Watson P, Hasegawa H, Roelands B, Piacentini M. Central fatigue: the serotonin hypothesis and beyond. *Sports Med*. 2006;36:881-909.
32. National Football League Policy on Performance-Enhancing Substances 2016. [https://nflpaweb.blob.core.windows.net/media/Default/PDFs/Agents/2016PESPolicy\\_v2.PDF](https://nflpaweb.blob.core.windows.net/media/Default/PDFs/Agents/2016PESPolicy_v2.PDF). Accessed January 1, 2017.
33. Nelson LD, Guskiewicz KM, Marshall SW, et al. Multiple self-reported concussions are more prevalent in athletes with ADHD and learning disability. *Clin J Sport Med*. 2016;26:120-127.
34. Parr JW. Attention-deficit hyperactivity disorder and the athlete: new advances and understanding. *Clin Sports Med*. 2011;30:591-610.
35. Perrin AE, Jotwani VM. Addressing the unique issues of student athletes with ADHD. *J Fam Pract*. 2014;63:E1-E9.
36. Perrin JM, Friedman RA, Knilans TK. Cardiovascular monitoring and stimulant drugs for attention deficit/hyperactivity disorder. *Pediatrics*. 2008;112:451-453.
37. Putukian M, Kreher JB, Coppel DB, Glazer JL, McKeag DB, White RD. Attention deficit hyperactivity disorder and the athlete: an American Medical Society for Sports Medicine position statement. *Clin J Sport Med*. 2011;21:392-401.
38. Reardon CL, Factor RM. A systematic review of diagnosis and medical treatment of mental illness in athletes. *Sports Med*. 2010;40:961-980.
39. Roelands B, Hasegawa H, Watson P, et al. The effects of acute dopamine reuptake inhibition on performance. *Med Sci Sports Exerc*. 2008;40:879-885.
40. Sawka MN, Young AJ, Latzka WA, Neuffer PD, Quigley MD, Pandolf KB. Human tolerance to heat strain during exercise: influence of hydration. *J Appl Physiol* (1985). 1992;73:368-375.
41. Seixas M, Weiss M, Müller U. Systematic review of national and international guidelines on attention-deficit hyperactivity disorder. *J Psychopharmacol*. 2012;26:753-765.
42. Subcommittee on Attention-Deficit/Hyperactivity Disorder. ADHD: clinical practice guideline for the diagnosis, evaluation, and treatment of attention-deficit/hyperactivity disorder in children and adolescents. *Pediatrics*. 2011;128:1007-1022.
43. Swart J, Lamberts RP, Lambert MI, et al. Exercising with reserve: evidence that the central nervous system regulates prolonged exercise performance. *Br J Sports Med*. 2009;43:782-788.
44. Vetter VL, Elia J, Erickson C, et al. Cardiovascular monitoring of children and adolescents with heart disease receiving medications for attention deficit/hyperactivity disorder. *Circulation*. 2008;117:2407-2423.
45. Wilens TE, Biederman J. Alcohol, drugs, and attention-deficit/hyperactivity disorder: a model for the study of addictions in youth. *J Psychopharmacol*. 2006;20:580-588.
46. Wilens TE, Prince JB, Spencer TJ, Biederman J. Stimulants and sudden death: what is a physician to do? *Pediatrics*. 2006;118:1215-1219.
47. Zuckerman SL, Lee YM, Odom MJ, Solomon GS, Sills AK. Baseline neurocognitive scores in athletes with attention deficit-spectrum disorders and/or learning disability. *J Neurosurg Pediatr*. 2013;12:103-109.

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