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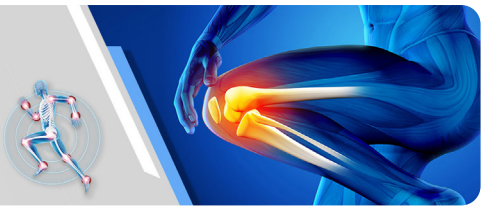

Mental Health and the Youth Athlete: An Analysis of the HeartBytes Database

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Abstract

Objective: To examine the relationship between mental health and athletic performance in youth athletes, and how antidepressant use can alter symptoms.

Design: Data was collected by Simon's Heart, a nonprofit organization that coordinates pre-participation examinations (PPE) for adolescents. Multivariable logistic regression was performed to assess the relationship between mental health disorders and each outcome.

Setting: There is a high rate of mental health conditions among adolescent athletes; however, there is limited information about its impact on their health and athletic performance.

Participants: Adolescent athletes participating in heart screenings performed by Simon's Heart.

Independent Variables: Anxiety/Depression, ADHD, Antidepressant Use, Stimulant Use.

Main Outcome Measures: ECG Abnormalities, Chest Pain/Dyspnea, Syncope, Palpitations.

Results: Screened participants without a diagnosis of ADHD or anxiety/depression were significantly more likely to play sports compared to those with these conditions. Those with anxiety/depression not on an antidepressant, but not those on an antidepressant, were more likely to report chest pain or dyspnea with exercise. Those with ADHD not on a stimulant, but not those on a stimulant were more likely to report palpitations.

Conclusion: Young athletes with anxiety/depression were less likely to participate in sports than healthy individuals. This deterrence may be due to symptoms they experience during exercise. However, those taking antidepressants had fewer symptoms during exercise. Given that exercise has been shown to improve depression/anxiety, increasing the rate of antidepressant use may lead to less symptoms, more exercise, and an overall improvement in mental health.

Keywords: Young athletes; Mental health disorders; Depression; HeartBytes Database

Introduction

There has been an increased focus on mental health conditions in athletes, with prominent athletes recently highlighting the mental health struggles

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faced by this unique population. Mental health disorders are common among athletes and may impair performance, increase risk for physical injury, and delay subsequent recovery [1,2]. For example, increased anxiety has been associated with worsening athletic performance in runners, and depression has been associated with reduced exercise capacity [3-6]. While there has been some research on the impact that mental health disorders can have on athletic performance, it is important to consider how these disorders may affect overall health in specific populations of athletes.

Youth athletes are a specific population at risk for developing mental health disorders. Approximately 8 million youth participated in interscholastic high school sports in the US during the 2018-2019 school year, and research has shown that a significant proportion of these individuals are affected by mental health disorders. For example, a 2019 study showed that almost one-third of male student athletes and almost one-half of female student athletes suffer from anxiety, and about 21% of male student athletes and 28% of female student athletes reported feeling depressed in the past 12 months [7]. Additionally, a 2016 study following 465 college athletes over 3 years showed that 23.7% of the student athletes reported a clinically relevant level of depressive symptoms, with 6.3% reporting moderate to severe depression [8]. Although there are mental health and social benefits associated with participating in youth sports, including increased confidence, positive body image, and increased self-esteem, stressors related to participating in sports may negatively affect mental health [9]. Factors such as lack of playing time, physical injury, overtraining, hazing, and sleep deprivation can have significant negative impacts on mental health [9]. Additionally, public stigma associated with mental health disorders that can be propagated by an athlete's parents, coaches, and teammates can prevent individuals from seeking beneficial mental health services [10]. With a potential increased risk of athletics negatively affecting mental health, it is important that more research is done to investigate the impact that this can have on the overall health of young athletes.

There is a known and complex relationship between mental illness and cardiovascular disease [8]. Individuals with severe mental illnesses are at a higher risk of developing cardiovascular disease and vice versa [11]. Individuals with depression are about one-third more likely than those without depression to develop chronic heart disease (CHD), myocardial infarction (MI), and coronary death [8]. Furthermore, those with anxiety also have a 41% increased risk for developing CHD [8]. Overall, mental health conditions have been shown to adversely affect cardiovascular health.

While there are numerous studies demonstrating the benefits of physical activity on cardiovascular health, including preventing the development of atherosclerosis and fatal arrhythmias, improving myocardial regeneration capacity, and improving cardiovascular risk factors, a few studies argue that the prolonged intense physical activity that athletes endure may also have negative impacts on cardiovascular health [12,13]. Young competitive athletes train between 10 to 20 hours per week at high intensities, potentially leading to adverse adaptations of the cardiovascular system, including severe cardiac arrythmia, coronary sclerosis, bradycardia, atrial dilatation, ventricular hypertrophy, and sudden cardiac death [14-16].

Given the prevalence of mental health issues in the youth athlete population, the potential negative effects that intense exercise can have on young athletes, and the impact mental health disorders can have on CV health, we sought to investigate the potential associations between mental health disorders, cardiovascular health, and symptoms during exercise in this specific population.

Methods

Data Source

This was a retrospective study of the HeartBytes National Youth Cardiac Registry database produced by Simon's Heart, a nonprofit with a mission of sudden cardiac death prevention in children and young adults by organizing pre-participation physicals and examinations. The HeartBytes database includes data on children aged 12 to 20 years old who were screened at a Simon's Heart pre-participation cardiac examination event between August 2014 to July 2021. During these events, self-reported information is collected on the patient's past medical history, medication use, family history, and participation in sport. The examination includes obtaining height, weight, and blood pressure measurement in addition to an electrocardiogram interpreted by a cardiologist at the event. ECGs were interpreted using the Seattle Criteria prior to 2017 and the International Criteria for Electrocardiographic Interpretation in Athletes after its publication in 2017. Of note, while we use the colloquial term ECG abnormalities to describe ECG findings generally considered different from the norm, many of these findings are normal in athletes, and this terminology does not reflect how ECGs were interpreted globally for the individual screened.

Statistical Analysis

Continuous variables are reported with mean and standard deviation for normally distributed variables or median and interquartile range for variables not normally distributed. Categorical variables are reported as counts and proportions. Continuous variables were compared with t-tests or Wilcoxon rank-sum test, and categorical variables were compared with the Pearson chi-square test. All statistical analyses were performed using RStudio version 1.3 (Boston, Massachusetts).

Vyas AJ, et al., J Ortho Sports Med 2024
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The primary outcomes of the study were electrocardiogram (ECG) abnormalities (specific abnormalities listed in Supplemental Table 1), symptoms of chest pain or dyspnea with exercise, syncope during or right after exercise, and palpitations at any time. Multivariable logistic regression was performed using either the patient's self-reported past medical history or medications, specifically antidepressants or stimulants, as a predictor for each outcome. Each logistic regression model was adjusted for age, sex, race, body mass index, asthma history, anemia history, and whether the patient played sports. Results are reported as adjusted odds ratios (aOR) with 95% confidence intervals (CI).

Results

The HeartBytes dataset is composed of screening data from 7425 patients that ranged from 12 to 20 years old (mean 15). The database is mostly male (60.6%). The patients screened were predominantly White (83.1%) with other represented races including Black (7.2%), Asian/Pacific Islander (3.8%), and Latino/Hispanic (3.2%). The mean body mass index was 20.9. Most of the patients were screened in Pennsylvania (61.6%), followed by New Jersey (18.8%) and then Georgia (9.5%) (Table 1).

Out of the 7,425 patients analyzed in the HeartBytes dataset, 370 participants (5.0%) were diagnosed with anxiety or depression (Table 1). The mean age of these participants was 15.4 years old, and exactly 50% of participants with these conditions were female compared to male. There was no significant difference when compared by self-reported race. A significantly higher percentage of participants without anxiety or depression played sports compared to those with these conditions (89.4% vs. 72.4%, P-value <0.001). Those with anxiety/depression were also more likely to have ADHD (2.2% vs 0.8%, P-value = 0.019) and asthma (21.9% vs. 17.6%, P-value = 0.041) compared to those without these conditions. There was no significant difference in the rates of diabetes or hypertension between the groups.

In our cohort, 565 (7.6%) were diagnosed with ADHD (Table 1). The mean age of the participants with ADHD was 15.21 years old and most of the participants diagnosed with ADHD were male compared to female (75.4% vs. 59.4%, P-value < 0.001). There was no significant difference when compared by self-reported race. Significantly more participants without ADHD played sports compared to those with ADHD (89.1% vs. 81.2% P-value <0.001). A significantly higher portion of participants with ADHD

Table 1: Demographics and tests of differences between individuals with and without anxiety/ depression or ADHD.

	Has Anxiety/ Depression	No Anxiety/ Depression	P-value	Has ADHD	No ADHD	P-value
Total Participants	370	7055		565	6860	
Age (mean (SD))	15.37 (1.95)	15.08 (1.86)	0.003	15.21 (1.96)	15.08 (1.86)	0.114
Male (%)	185 (50.0)	4317 (61.2)	<0.001	426 (75.4)	4076 (59.4)	<0.001
Race (%)			0.303			0.147
White	317 (86.1)	5854 (83.8)	N/A	485 (85.8)	5686 (83.8)	N/A
Asian/ Pacific Islander	6 (1.6)	207 (3.0)	N/A	7 (1.2)	206 (3.0)	N/A
Black	21 (5.7)	514 (7.4)	N/A	38 (6.7)	497 (7.3)	N/A
Latino/Hispanic	15 (4.1)	217 (3.1)	N/A	17 (3.0)	215 (3.2)	N/A
Other	9 (2.4)	193 (2.8)	N/A	18 (3.2)	184 (2.7)	N/A
BMI (mean (SD))	21.53 (4.36)	21.54 (4.39)	0.957	21.77 (5.58)	21.51 (4.28)	0.201
Plays Sports (%)	268 (72.4)	6298 (89.4)	<0.001	457 (81.2)	6109 (89.1)	<0.001
High Blood Pressure (%)	2 (0.5)	16 (0.2)	0.513	1 (0.2)	17 (0.2)	1.000
Asthma (%)	81 (21.9)	1241 (17.6)	0.041	118 (20.9)	1204 (17.6)	0.053
Diabetes (%)	1 (0.3)	19 (0.3)	1.000	1 (0.2)	19 (0.3)	0.985
Anemia (%)	96 (25.9)	469 (6.6)	<0.001	4 (0.7)	63 (0.9)	0.782
ADHD (%)	8 (2.2)	59 (0.8)	0.019			
Anxiety/Depression (%)				96 (17.0)	274 (4.0)	<0.001
Taking Antidepressant (%)	99 (26.8)	25 (0.4)	<0.001	36 (6.4)	88 (1.3)	<0.001

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Vyas AJ, et al., J Ortho Sports Med 2024
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took antidepressants (6.4% vs. 1.3%, P-value of <0.001). There were no significant differences in the prevalence of hypertension, diabetes, or BMI when comparing between participants with and without ADHD.

ECG abnormalities were present in 194 (2.6%) patients with the most commonly reported being T wave inversion (61 patients, 0.8%) and nonspecific ST-T wave abnormalities (30 patients, 0.4%; Supplemental Table 1).

After adjusting for age, gender, race, BMI, medical conditions of anemia and asthma, and participation in sports, those with anxiety/depression (aOR 1.03, CI 0.48 – 1.95, P-value = 0.930) and those with ADHD (aOR 0.84, CI 0.45 – 1.44, P-value = 0.550) were no more likely to have an ECG abnormality compared to the participants without these conditions (Table 2). The same population was no more likely to have syncope with exercise (anxiety/depression: OR 1.75, CI 0.79 – 3.45, P-value = 0.13) (ADHD: aOR 1.08, CI 0.44 – 2.26, P-value = 0.84) compared to participants without these conditions. However, those with anxiety/depression (aOR 2.35, CI 1.65 – 3.28, P-value < 0.001) but not those with ADHD (aOR 1.45, CI 1.02 – 2.03, P-value = 0.05) were more likely to have experienced palpitations. Lastly, participants with anxiety/depression (aOR 1.92, CI 1.30 – 2.77, P-value < 0.001) but not ADHD (aOR 1.26, CI 0.87 – 1.79, P-value = 0.20) were more likely to have any chest pain or dyspnea with exercise (Table 2).

After adjusting for age, gender, race, BMI, asthma, anemia, and whether the patient plays sports, those who take an antidepressant (aOR 1.10, CI 0.33 – 2.69, p = 0.85) and those who take a stimulant (aOR 0.53, CI 0.19 – 1.18, p = 0.17) were no more likely to have an ECG abnormality (Table 3). The same result was found with regards to chest pain and dyspnea with exercise in these populations (aOR 1.54, CI 0.83 – 2.66, P-value = 0.14 for antidepressants; aOR 1.39, CI 0.87 – 2.14, P-value = 0.15 for stimulants). In addition, participants who take an antidepressant (aOR 1.66, CI 0.49 – 4.20, P-value = 0.34) or a stimulant (aOR 0.50, CI 0.01 – 1.61, p = 0.33) were no more likely to have syncope with exercise. Notably, patients taking an antidepressant (aOR 2.09, CI 1.23 – 3.36, p < 0.01) were more likely to report palpitations, but not those who take a stimulant (aOR 1.22, CI 0.75 – 1.89, p = 0.39) (Table 3).

We then examined the effects of antidepressants and stimulants on these variables. After again adjusting for age, gender, race, BMI, asthma, anemia, and participation in athletics, those with anxiety/depression not on medication (aOR 2.09, CI 1.31 – 3.19, p < 0.01), but not those with anxiety and depression on medication (aOR 1.87, CI 0.96 – 3.33, p = 0.05), were more likely to report chest pain or

Table 2: Effect of mental health conditions on cardiovascular symptoms.

Mental Health Condition	Cardiovascular Outcomes	Adjusted Odds Ratio	Confidence Interval	P-value
Anxiety/Depression	ECG Abnormalities	1.03	0.48-1.95	0.930
	Chest Pain or Dyspnea	1.92	1.30-2.77	<0.001
	Syncope	1.75	0.79-3.45	0.13
	Palpitations	2.35	1.65-3.28	<0.001
ADHD	ECG Abnormalities	0.84	0.45-1.44	0.550
	Chest Pain or Dyspnea	1.26	0.87-1.79	0.200
	Syncope	1.08	0.44-2.26	0.84
	Palpitations	1.45	1.02-2.03	0.05

Table 3: Effect of psychiatric medications on cardiovascular symptoms.

Mental Health Medication	Cardiovascular Symptom	Adjusted Odds Ratio	Confidence Interval	P-value
Antidepressant	ECG abnormalities	1.10	0.33-2.69	0.85
	Chest Pain or Dyspnea	1.54	0.83-2.66	0.14
	Syncope	1.66	0.49-4.20	0.34
	Palpitations	2.09	1.23-3.36	<0.01
Stimulant	ECG Abnormalities	0.53	0.19-1.18	0.17
	Chest Pain or Dyspnea	1.39	0.87-2.14	0.15
	Syncope	0.50	0.01-1.61	0.33
	Palpitations	1.22	0.75-1.89	0.39

Vyas AJ, et al., J Ortho Sports Med 2024
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Table 4: Effect of medications on youth athletes diagnosed with mental health conditions.

	No anxiety/depression	Anxiety/depression on Medication	p-value	Anxiety/depression not on Medication	p-value
ECG Abnormalities	--	0.65 (0.11 – 2.07)	0.55	1.18 (0.49 – 2.37)	0.68
Chest Pain or Dyspnea	--	1.87 (0.96 – 3.33)	0.05	2.09 (1.31 – 3.19)	<0.01
Palpitations	--	2.18 (1.19 – 3.73)	<0.01	2.69 (1.78 – 3.95)	<0.001
	No ADHD	ADHD on stimulant		ADHD not on stimulant	p-value
ECG Abnormalities	--	0.66 (0.23 – 1.46)	0.36	1.02 (0.45 – 1.97)	0.96
Chest Pain or Dyspnea	--	1.50 (0.90 – 2.38)	0.10	1.31 (0.79 – 2.07)	0.27
Palpitations	--	1.40 (0.82 – 2.24)	0.19	1.91 (1.22 – 2.89)	<0.01

dyspnea with exercise. Regardless of medication use, those with anxiety/depression were at increased risk of palpitations but not ECG abnormalities (Table 4).

Reported history of ADHD by medication use was then evaluated. After adjustment for confounders, those with ADHD not on stimulants (aOR 1.91, CI 1.22 – 2.89, $p < 0.01$), but not those on a stimulant (aOR 1.40, CI 0.82 – 2.24, $p = 0.19$), were at increased risk for palpitations compared to those without ADHD. In those with ADHD regardless of prescribed medication, no difference was present for ECG abnormalities or chest pain/dyspnea with exercise compared to those without ADHD (Table 4).

Discussion

This analysis of the HeartBytes database compared young athletes with ADHD, anxiety, and depression to those without these diagnoses. We also compared individuals who were receiving pharmacotherapy for mental health disorders with those not being treated with medications. In our multivariable analysis, those with anxiety/depression not taking antidepressants were more likely to report chest pain or dyspnea with exercise. Those with ADHD who were not taking stimulants were more likely to report palpitations. Importantly, we did not observe any associations between ECG abnormalities or cardiovascular comorbidities (such as hypertension or diabetes) and specific mental health conditions or medications.

Patients diagnosed with anxiety/depression were significantly less likely to participate in sports. These findings are similar to those found in other studies examining trends in sports participation among adolescents [17-19]. This is significant, as prior data has suggested that exercise can be used to treat anxiety or depression [21,22]. In a 2007 study, 45% of participants experienced full remission of Major Depressive Disorder with supervised exercise alone [22]. Additional studies have shown a significant decrease in depressive symptoms with sports participation, specifically in team sports, for college students [23]. Exercise has also been shown to be effective when used as an adjunct to pharmacologic treatment of depression [24]. These effects can be attributed to increased synaptic plasticity, neurotransmission, and neuronal activation with exercise [25-27]. Similar positive effects are seen in patients with anxiety, however further research in this area is necessary before more definitive conclusions can be made [24].

Notably, only 26.8% of individuals in this study with anxiety/depression were prescribed pharmacological therapy. This is especially important because it has been shown that only about 15-30% of children and adolescents with depression respond well to non-pharmacologic therapy alone [28,29]. Antidepressants, in general, have been shown to alter symptoms typical in depression, such as chest pain, dyspnea, insomnia, and anhedonia [30-32]. SSRI/SNRIs specifically have been shown to improve insomnia and chest pain symptoms in individuals with depression [33-35].

The results of our study show that young individuals with anxiety/depression are more likely to experience symptoms during exercise. However, our data also demonstrates that individuals with these conditions taking antidepressants are significantly less likely to experience chest pain or dyspnea. We show that those with anxiety/depression are less likely to participate in sports, which could be partially attributed to symptoms they experience. Based on this information, increasing the rates of individuals appropriately prescribed antidepressants has the potential to decrease symptoms during exercise in this population and subsequently promote exercise and participation in athletics. Given that exercise has been shown to improve depressive symptoms, increasing the rate of antidepressant use may lead to less symptoms, more exercise, and an overall improvement in the mental health

conditions in this population. Similarly, we show that those with ADHD being treated with stimulants were less likely to experience palpitations, so increasing pharmacologic treatment rates in this population could help improve their symptoms and promote exercise, as well.

Our study has several limitations. Firstly, the data on mental illness, medications, and symptoms during exercise are self-reported and therefore subject to recall bias. Additionally, information on medication dosage, medication adherence, use of non-pharmacologic therapy, and severity of mental health disorders was not obtained. Furthermore, anxiety and depression were combined as one variable in the questionnaire, and so we were unable to analyze these two disorders individually.

Much more research is needed on mental health disorders, pharmacologic treatment, and exercise. For example, future studies should focus on identifying which specific medications are most effective in reducing symptoms during exercise. Similarly, investigating the impact of different exercises or participation in specific sports on anxiety/depression symptoms could provide valuable information to help guide treatment plans for individuals with these conditions. It will also be important to include other psychiatric disorders in future studies related to this topic.

While further research in this area is certainly necessary, our preliminary data has demonstrated the potential profound impact that increasing the pharmacologic treatment rates for anxiety/depression may have on the youth population and their mental health conditions.

Compliance with Ethical Standards

Ethical Approval: Not applicable.

Competing interests: Not applicable.

Authors' contributions: A.V. and M.S. contributed equally to this work.

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Availability of data and materials: Data is available via HeartBytes, a HIPPA compliant database. Information is available free of charge to qualified researchers.

Informed consent: Data in the HeartBytes database is collected from organizations that conduct youth heart screenings, consent is received from the parents of participants prior to data gathering. This information is de-identified and HIPPA compliant.

Declaration Statement: The authors of this paper have no conflicts of interest to disclose.

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Vyas AJ, et al., J Ortho Sports Med 2024
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SUPPLEMENTARY FILES

Supplemental Table 1: Incidence of individual ECG abnormalities examined in this study.

ECG Abnormality	Incidence in Study Cohort (%)
Any ECG Abnormality	194 (2.6)
T Wave Inversion	61 (0.8)
ST Segment Depression	5 (0.1)
Nonspecific ST-T Wave Abnormality	30 (0.4)
Early Repolarization	20 (0.3)
Intraventricular Conduction Delay	25 (0.3)
Left Axis Deviation	13 (0.2)
Left Atrial Enlargement	20 (0.3)
Right Ventricular Hypertrophy Pattern	12 (0.2)
Ventricular Pre-Excitation	6 (0.1)
Long QT Interval	11 (0.1)
Brugada-Like ECG Pattern	5 (0.1)
Premature Ventricular Complexes	7 (0.1)
Ventricular Arrhythmia	1 (0.0)