Heart at risk: anabolic steroids and the search for a perfect body

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Summary

Introduction: Anabolic androgenic steroids (AAS) have been known to enhance muscle development, yet they have also been associated with detrimental cardiovascular changes in both the heart and blood vessels.
Objectives: This study aimed to identify electrocardiographic changes in individuals consuming anabolic steroids in relation to body image enhancement.
Material and method: We conducted a descriptive cross-sectional study among individuals using AAS for body image improvement and engaging in amateur gym training. Electrocardiographic changes were assessed according to international criteria for electrocardiogram interpretation in amateur athletes. Two experts independently analyzed the electrocardiograms, along with collecting data such as duration of consumption, age, and gender.
Results: Twelve-lead electrocardiograms were obtained from 23 participants, with 95.4% being male and 4.6% female, recruited through snowball sampling. Exercise-related changes, deemed expected per international criteria for electrocardiogram interpretation in amateur athletes, were observed, alongside findings considered borderline. However, abnormal changes were identified in 7 individuals, including anterior T-wave inversion (4.35%), complete left bundle branch block (4.35%), prolonged QT interval (4.35%), left posterior block (4.35%), and nonspecific ST-segment depression with left ventricular hypertrophy (4.35%).
Conclusions: Several electrocardiographic abnormalities were identified, which could pose serious implications, with over 50% of participants exhibiting borderline changes associated with anabolic steroid use. Further longitudinal and associative studies are warranted to comprehend their impact on the cardiovascular system. Developing public policies involving increased state control of these substances and promoting supervision by healthcare professionals is imperative.

Key words:
Anabolic agents. Electrocardiography. Bundle-branch block. Cardiomegaly.

Corazón en riesgo: esteroides anabólicos y la búsqueda de la perfección corporal

Resumen

Introducción: Los esteroides androgénicos anabólicos (EAA) potencian el desarrollo muscular y han estado asociados a cambios cardiovasculares deletéreos para el corazón y los vasos.
Objetivos: Identificar cambios electrocardiográficos en personas consumidoras de anabólicos esteroides relacionadas con la mejoría de la imagen corporal.
Material y método: Se realizó un estudio descriptivo de corte transversal en personas consumidoras de EAA relacionada con la mejoría de la imagen corporal y el entrenamiento aficionado en gimnasios. Se analizaron los cambios electrocardiográficos según los criterios internacionales para la interpretación del electrocardiograma para deportistas aficionados. Los electrocardiogramas fueron analizados por dos expertos de forma independiente, además se incluyeron datos como el tiempo de consumo, edad y sexo.
Resultados: Se tomó un electrocardiograma de 12 derivaciones a 23 participantes, el 95,4% fueron hombres y el 4,6% mujeres, dichos sujetos fueron reclutados en bola de nieve. Se encontraron cambios relacionados con el ejercicio físico que se han descrito como esperados en los criterios internacionales para la interpretación del electrocardiograma para deportistas aficionados, así como hallazgos considerados limítrofes; Sin embargo; en 7 personas se encontraron cambios anormales entre los cuales se destaca inversión de la onda T anterior (4,35%), bloqueo completo de rama izquierda (4,35%), prolongación del intervalo QT (4,35%), bloqueo del fascículo posterior izquierdo (4,35%) y trastorno no especifico de la repolarización pared inferior con la hipertrofia cardiaca izquierda (4,35%).
Conclusiones: Se identificaron varias anormalidades electrocardiográficas que podrían generar complicaciones graves y más del 50% presento cambios limítrofes concomitantes al uso de anabólicos; no obstante, se requieren estudios de seguimiento y asociación para analizar su impacto en el sistema cardiovascular. Es importante desarrollar políticas públicas relacionadas con un mayor control estatal de estas sustancias y la promoción de la supervisión por profesionales de la salud.

Palabras clave:
Anabolizantes. Electrocardiografía. Bloqueo de rama. Cardiomegalia.

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Introduction

Synthetic testosterone derivatives, or anabolic-androgenic steroids (AAS), are male sex hormones with predominantly anabolic effects (skeletal muscle hypertrophy) when compared with their androgenic effects (development of male sexual characteristics). This has led to indiscriminate consumption in people looking to change their body image[1,2]. In a meta-analysis that included 162 articles involving 697,357 people (581,595 men and 341,448 women) aged 20.15 years on average from 118 countries on five continents (America, Europe, Oceania, Africa and Asia), Sagoe, *et al.*, reported a global AAS consumption prevalence of 6.4% in men and 1.6% in women[3,4].

The situation in Latin America is similar to that reported worldwide. In Brazil, the prevalence among men has been reported at 8.1% and among women at 0.4%. In Argentina and Colombia, it stands at around 6.5%, and concerns around body image have been highlighted as one of the main causes[5,6]. The consumption of AAS has transcended high-performance sport into amateur sports practice, especially among adolescents and young adults. Consumption tends to begin between the ages of 22 and 24 years, and at least between 2.7% and 2.9% of young adults have used AAS at least once in their lifetime[7].

Furthermore, muscle dysmorphic syndrome (vigorexia) can also lead to the use and indiscriminate abuse of AAS in an attempt to achieve the desired body. Multiple commercial presentations of these substances can be found in the market that, combined with various consumption and duration patterns, pose significant health risks. Nonetheless, overdosing seems to be the greatest problem; with estimates claiming that consumption varies between 10 and 100 times the recommended therapeutic dose, which varies between 250 and 3,200 mg per week[1,2].

The practice of sport, whether professional or amateur, induces changes to cardiac electrophysiology. The reported changes include sinus bradycardia, heart conduction disorders (such as first-degree atrioventricular (AV) block and Mobitz type I second-degree atrioventricular (AV) block), increased QRS complex voltage, right axis deviation of the QRS electrical axis, jagged QRS and prolongation of the corrected QT interval (QTc) to values in the upper boundary range. However, greater alterations may also occur with links to exogenous AAS supplementation[8].

The electrocardiographic changes associated with AAS consumption are diverse and vary in severity. They can include ventricular arrhythmias, acute myocardial infarction and even sudden death. It is possible to observe prolongation of the QTc interval, increased QT dispersion, increased heart rate post physical effort when compared with non-consumers, prolongation of the JT interval, sinus rhythm with a QI-SIII pattern, T-wave inversion and left ventricular hypertrophy[9]. These alterations are related to autonomic cardiac dysregulation and have been linked to the consumption of higher than therapeutic doses over more than two years and in multiple cycles[9-13].

The indiscriminate use of these substances is considered a public health problem given that there is scientific evidence to show the negative secondary effects that compromise health. Special attention has recently been given to their role in the development of cardiovascular, psychological and endocrine anomalies, among others. However, the regulations that currently exist in different countries continue to be neglected[14]. This study sought to identify electrocardiographic changes in people who consume anabolic steroids linked to the improvement of body image according to international criteria for the interpretation of electrocardiograms in amateur athletes[14].

Material and Method

This is a cross-sectional study. The participants were people who attend fitness centres and gyms in Colombia. Non-probabilistic sampling was used, based on the snowball technique in which each identified participant would refer the next. 26 people were recruited, of which 24 met the criteria for inclusion (people aged over 18 years who have consumed any AAS derivative, oral or injected, for a period of more than two years and in doses greater than 100 mg, who also signed the informed consent form). Of these, 23 effectively signed the informed consent form. Pregnant women and people with diagnosed cardiovascular disease or a serious medical history were excluded. This study was backed by the institutional ethics committee and the findings were duly shared with participants, and those potentially needing medical attention were referred to the pertinent specialists.

A 12-lead electrocardiogram (ECG) was performed on each participant. They were asked to refrain from ingesting any stimulating drinks during the day before the test (such as drinks with caffeine or tobacco) and from engaging in any physical exercise beforehand. The test was conducted in the physiology lab at a temperature of 24 degrees centigrade and a relative humidity of 40-50%. The procedure was conducted by a nursing professional. Analysis of each ECG was carried out independently, firstly by a physiotherapist and then by a cardiologist subspecialising in cardiac electrophysiology, based on international criteria for the interpretation of electrocardiograms in professional and amateur athletes. Said criteria classify findings into three categories: expected or normal changes (findings related to training that are considered physiological), borderline findings (formerly catalogued as abnormal but that may be present without leading to complications) and abnormal or serious findings (that could pose a risk of complications)[15,16].

The validated Spanish version of the Drezner, *et al.* questionnaire was used[17,18]. To protect the confidentiality of participants and respect their privacy, they were allowed to only answer those questions they deemed appropriate or pertinent.

The Stata® package was used for statistical analysis. Nominal variables were expressed in frequencies and proportions, while continuous variables were analysed using central tendency and dispersion techniques. Hypothesis tests were performed to evaluate differences in averages and proportions as necessary (Kruskal-Wallis and Fisher test).

Results

To conduct this study, 12-lead electrocardiograms (ECG) were taken from 23 people who had previously signed the informed consent form and were consuming AAS. The participants were attending fitness centres regularly, at least five times a week. Of the people included in the study, 22 were men (95.6%) and one woman (4.4%). Their average age was 31.6 years. The most used AAS was testosterone decanoate (26.08%). The predominant route of administration was intramuscular, being used by 22 participants (95.6%), and the average period of using the substance was 2.8 years, with at least two cycles per year. The majority of participants were engaged in strength training (52.17%), with an average of 171.2 minutes of training per week (Table 1).

Table 2 shows the electrocardiographic and general cardiovascular characteristics. The average heart rate was 68.3 beats per minute, a value that stands below the general population average reported in literature, with a statistically significant difference (p <0.001). The average systolic blood pressure was 130.2 mmHg, a higher than expected value for the age, while the average diastolic blood pressure was 80.3 mmHg. Both differences were statistically significant (p <0.001).

Table 1. Sociodemographic characteristics of the people consuming anabolic steroids (n = 23).

Variable	n = 23
Gender (%)	
Male	22 (95.4%)
Female	1 (4.6%)
Age in years per gender (s.d.)	
Male	31.6 (11.2)
Female	22 (0.0)
Type of anabolic steroid and weekly anabolic dose (%)	
Testosterone enanthate 250mg	1 (4.35)
Methandrostenolone 160mg	1 (4.35)
Boldenone undecylenate 400mg	1 (4.35)
Testosterone enanthate 300mg	1 (4.35)
Testosterone decanoate 100mg	6 (26.08)
Testosterone propionate 100mg	3 (17.39)
Testosterone propionate 150mg	1 (4.35)
Testosterone cypionate 250mg	1 (4.35)
Combined presentation *(1ml= testosterone propionate 30mg +testosterone phenylpropionate 60 mg + testosterone isocaproate 60 mg + testos*terone decanoate 100 mg + excipients c.s.p 1 mg/1 ml)	3 (13.04)
Other anabolics and periods of consumption	
Stanozolol 100mg every 3 weeks	5 (21.74)
Route of administration (%)	
Intramuscular	22 (95.6)
Oral	1 (4.35)
Period of consumption in years (s.d.)	2,8 (1.2)
Type of training (%)	
Power	11 (47.83)
Strength	12 (52.17)
Speed	0 (0)
Stamina	0 (0)

s.d.: standard deviation; excipients c.s.p: excipients and sufficient quantity for 1 g, 10 ml.

Table 2. Electrocardiographic and general cardiovascular characteristics.

Variable	Men = 22	Women = 1
Heart rate bpm (s.d.)	68.3 (6.8)*	52.2 (0.0)*
Systolic blood pressure (s.d.)	130.2 (4.5)*	121 (0.0)
Diastolic blood pressure (s.d.)	80.9 (1.3)	78 (0.0)
Rhythm % (n)		
Sinus	100 (22)	100 (1)
AV	0 (0)	0 (0)
Purkinje	0 (0)	0 (0)
Cardiac electrical axis % (n)		
Normal	72.7 (16)	1 (100)
Right	13.60 (3)	0 (0)
Left	13.60 (3)	0 (0)
Undetermined	0 (0)	0 (0)
Intervals		
P-R (s)	0.19 (0.04)	0.20 (0.0)
Q-T (s)	0.36 (0.03)	0.46 (0.0)
QRS voltage mV (s.d.)	0.97 (0.34)	
ECGs with no relevant changes % (n)	36.36 (8)	100 (1)
Expected findings from the ECG on the athlete % (n)	18.18 (4)	0 (0)
Borderline disorders from the ECG on the athlete % (n)	13.63 (3)	0 (0)
Serious disorders from the ECG on the athlete % (n)	31.81 (7)	0 (0)

*p<0.001 t Student, univariate test, AV: atrioventricular, ECG: electrocardiogram, N/A: not applicable.

In terms of the electrocardiographic parameters, all participants presented sinus rhythm. 73.9% showed a QRS electrical axis of between 0° and 90°, while 13% showed a deviation of the electrical axis to the right and another 13% to the left. Upon analysis of the QRS complex duration, wave voltage, segments and intervals, no statistically significant differences were found from expected results[13]. Changes considered normal in the ECG of amateur athletes were observed in 18 people, while three presented borderline findings and seven showed serious disorders in their ECG.

Table 3 characterises the normal ECG findings in amateur athletes based on the type of AAS consumed. Heart rate and rhythm were not affected by any anabolic steroid. The heart axis showed a deviation to the right in one participant (4.35%) who was consuming testosterone decanoate and in two participants (8.7%) who were consuming stanozolol. Furthermore, one participant (4.35%) presented a deviation to the left and was consuming testosterone decanoate, testosterone propionate and a combination of steroids. One case of left ventricular hypertrophy was also observed, as well as incomplete right bundle branch block in consumers of testosterone enanthate and testosterone propionate. However, these findings showed no statistically significant link.

Table 4 describes the electrocardiographic characteristics and borderline findings based on the type of AAS consumed. Left atrial enlargement was identified in one participant who was consuming testosterone decanoate (Figure 1) and in another who was consuming testosterone propionate (4.35%).

Table 3. General electrocardiographic characteristics and expected findings from the ECG on the subjects based on the type of anabolic consumed and gender.

Medicine	Gender	Heart rate (s.d.)	Sinus rhythm (%)	Electrical axis (Offset: n, %)	Heart blocks (%)*	Left ventricular hypertrophy (%)	Total, findings
Testosterone enanthate	Male	71 (1.2)	1 (4.35)	0 (0)	Incomplete: 0 (0)	1 (4.35)	2
Methandrostenolone	Male	55 (2.7)	1 (4.35)	0 (0)	Incomplete: 0 (0)	0 (0)	1
	Female	<50	1 (4.35)	0 (0)	N/A	N/A	1
Boldenone undecylenate	Male	71 (1.9)	1 (4.35)	0 (0)	First degree: 1 (4.35)	0 (0)	2
Testosterone enanthate	Male	65 (1.2)	1 (4.35)	0 (0)	Incomplete: 1 (4.35)	0 (0)	2
Testosterone decanoate	Male	69.1 (1.9)	5 (21.74)	Left: 1 (4.35)	0 (0)	0 (0)	7
Testosterone cypionate	Male	69 (2.8)	1 (4.35)	0 (0)	0 (0)	0 (0)	1
Stanozolol	Male	70 (5.3)	5 (21.74)	0 (0)	0 (0)	0 (0)	5
Testosterone propionate	Male	71.3 (11.3)	4 (17.39)	Left: 1 (4.35)	Incomplete: 1 (4.35)	0 (0)	6
Combination	Male	63 (9.1)	3 (13.04)	Left: 1 (4.35)	0 (0)	0 (0)	4

Fisher Test, +Kwallis Test.

Table 4. Electrocardiographic characteristics and borderline findings from the ECG on the athlete based on the type of anabolic consumed.

	Testosterone enanthate	Methandrostenolone	Boldenone undecylenate	Testosterone enanthate	Testosterone decanoate	Testosterone cypionate	Stanozolol	Testosterone propionate	Combination	*p*
Left atrial enlargement	0 (0)	0 (0)	0 (0)	0 (0)	1 (4.35)	0 (0)	0 (0)	1 (4.35)	0 (0)	0.81

Fisher Test.

Table 5. Electrocardiographic characteristics and abnormal findings from the electrocardiogram on the athlete based on the type of anabolic consumed (n = 23).

	Testosterone enanthate	Methandrostenolone	Boldenone undecylenate	Testosterone enanthate	Testosterone decanoate	Testosterone cypionate	Stanozolol	Testosterone propionate	Combination	*p*
Anterior T-wave inversion	0 (0)	0 (0)	1 (4.35)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.21
Complete left bundle branch block	0 (0)	0 (0)	1 (4.35)	0 (0)	0 (0)	0 (0)	1 (4.35)	0 (0)	1 (4.35)	0.30
Prolonged QT interval	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (4.35)	0 (0)	0 (0)	0.71
Left posterior fascicular block	0 (0)	0 (0)	0 (0)	0 (0)	1 (4.35)	0 (0)	1 (4.35)	0 (0)	1 (4.35)	0.94
Non-specific left wall repolarisation disorder	0 (0)	0 (0)	0 (0)	0 (0)	1 (4.35)	0 (0)	0 (0)	0 (0)	0 (0)	1.01

Fisher Test.

Table 5 shows the electrocardiographic characteristics and abnormal findings based on the type of AAS consumed. Anterior T-wave inversion was found in one participant (Figure 2), incomplete right bundle branch block in another (Figure 3) and prolongation of the QT interval in one consumer of stanozolol (Figure 4). Left posterior fascicular block was also observed in one consumer of testosterone decanoate (Figure 5) and a non-specific inferior wall repolarisation disorder (Figure 6). No statistically significant differences were found between the substances being consumed..

Discussion

Electrocardiographic changes in people who consume anabolic-androgenic steroids (AAS) for the purpose of improving their body

Figure 1. Electrocardiogram case 8. Sinus rhythm, Heart Rate: 75 per minute, electrical axis -15°, Left atrial enlargement. Testosterone decanoate 100mg/week intramuscular, 160 minutes of strength training.

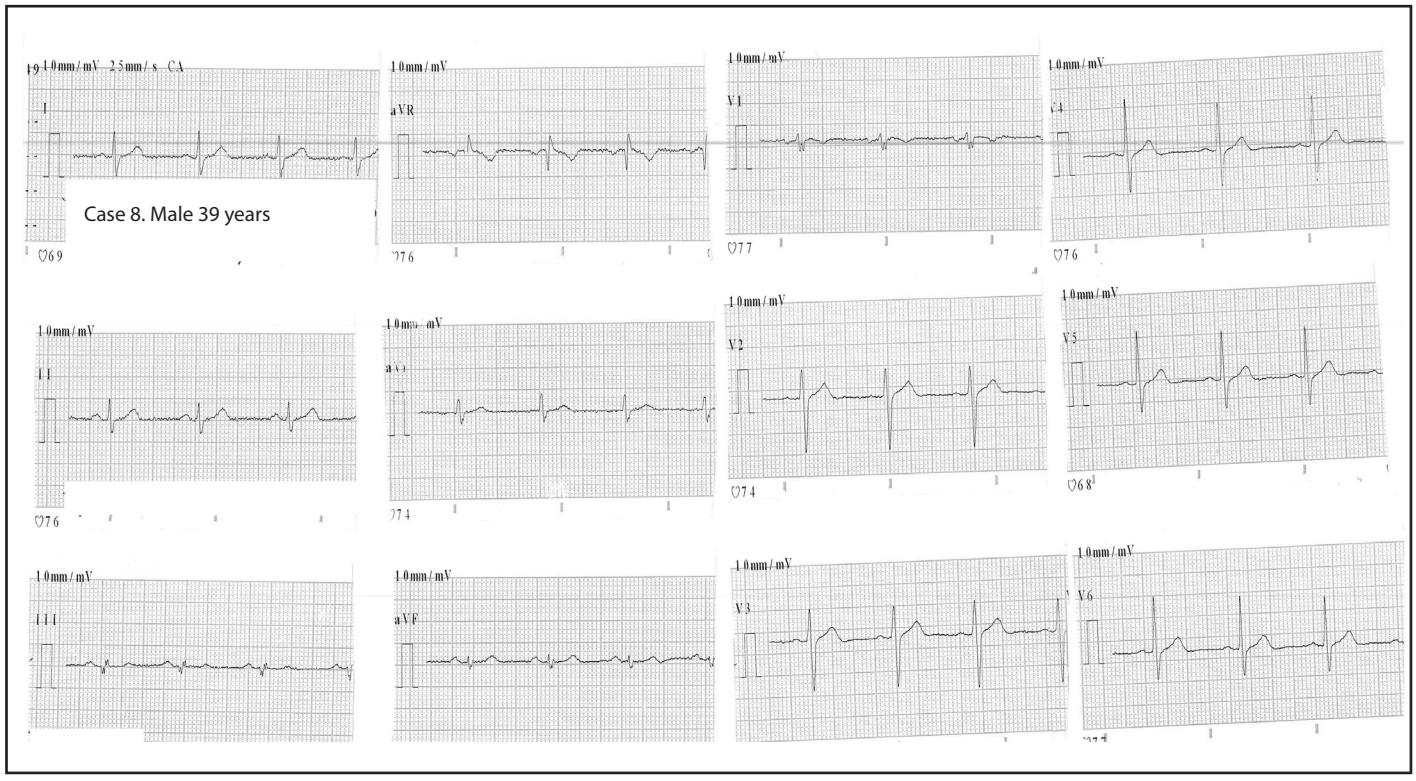

Figure 2. Electrocardiogram case 3. Sinus rhythm, Heart Rate: 71 per minute, electrical axis +60º, Non-specific left wall repolarisation disorder (asymmetrical inverted T-waves) Boldenone undecylenate 400 mg/week intramuscular, 180 minutes of Crossfit-type training.

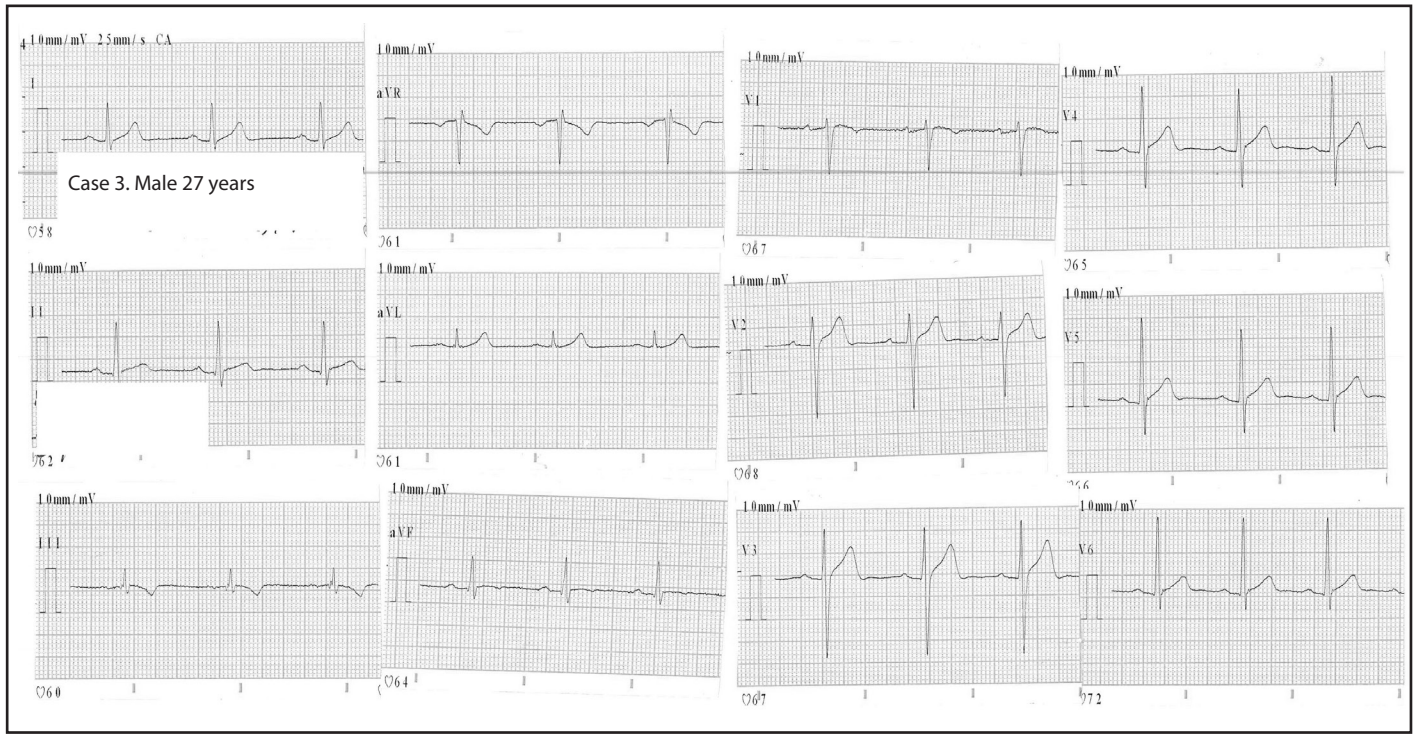

Figure 3. Electrocardiogram case 4. Sinus rhythm, Heart Rate: 65 per minute, electrical axis 0º, Incomplete block of the right branch of the bundle of His. Testosterone enanthate 300mg/week intramuscular, three cycles per year, 200 minutes of strength training per week.

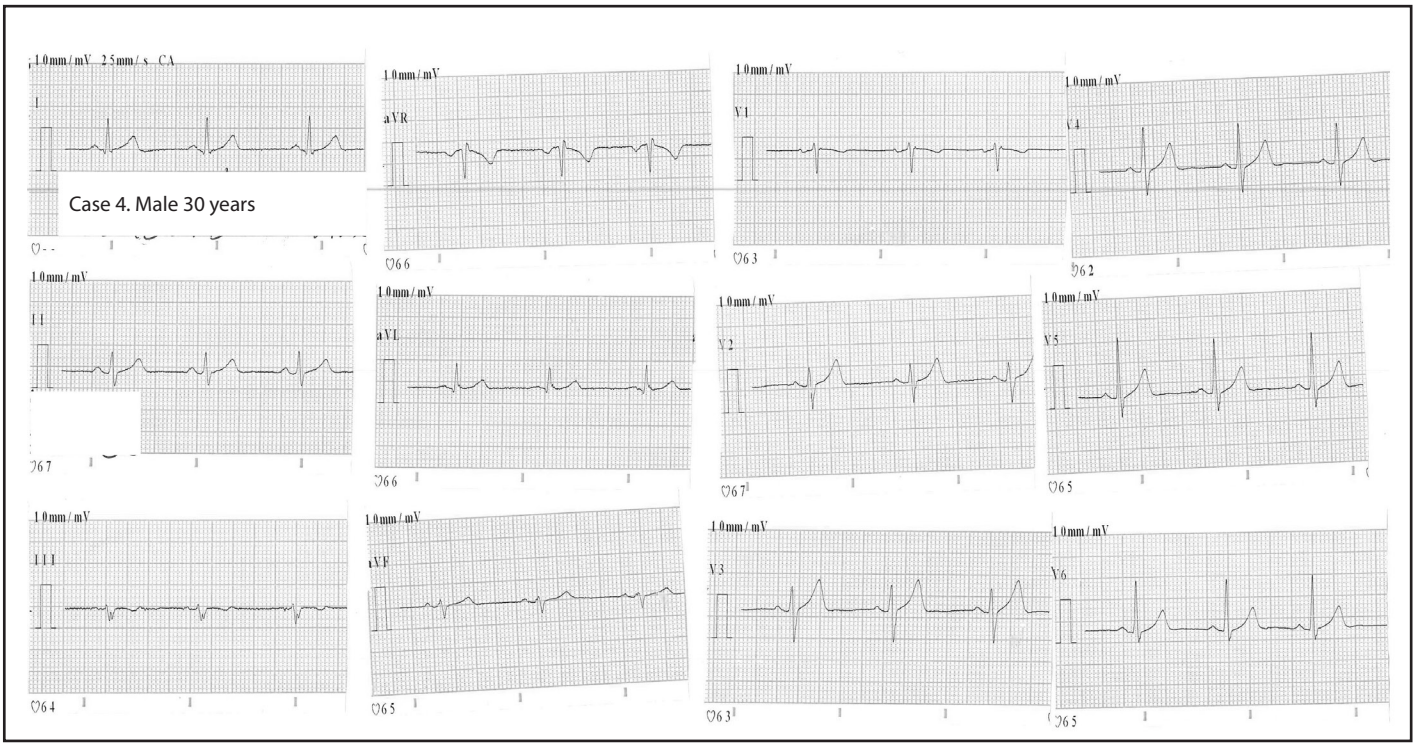

Figure 4. Electrocardiogram case 12. Sinus rhythm, Heart Rate: 78 per minute, electrical axis +90º, QTc interval of 365 ms higher than expected, Stanozolol 50mg every 3 weeks intramuscular, 90 minutes of CrossFit training with a focus on strength.

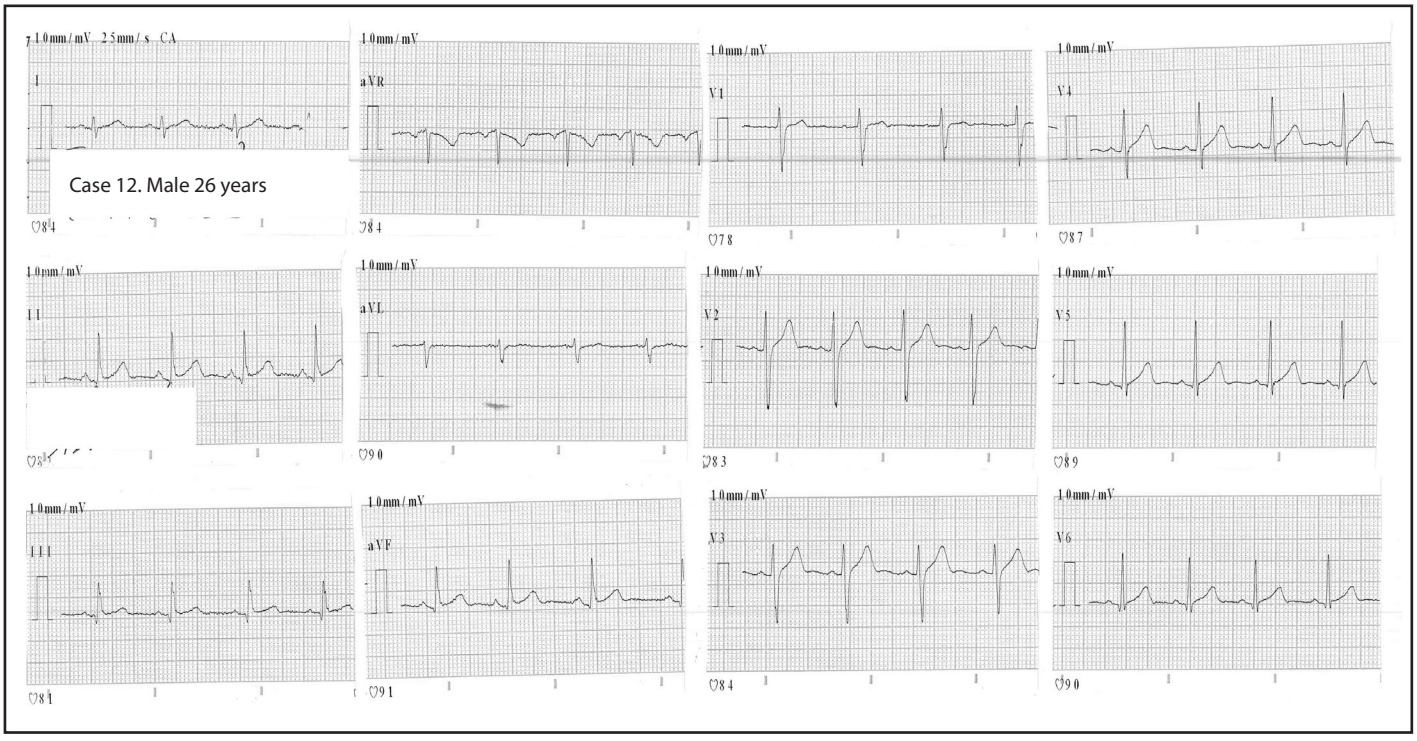

Figure 5. Electrocardiogram case 6. Sinus rhythm, Heart Rate: 68 per minute, electrical axis +120º, Left posterior fascicular block. Testosterone decanoate 100mg/week intramuscular, 75 minutes of strength training per week.

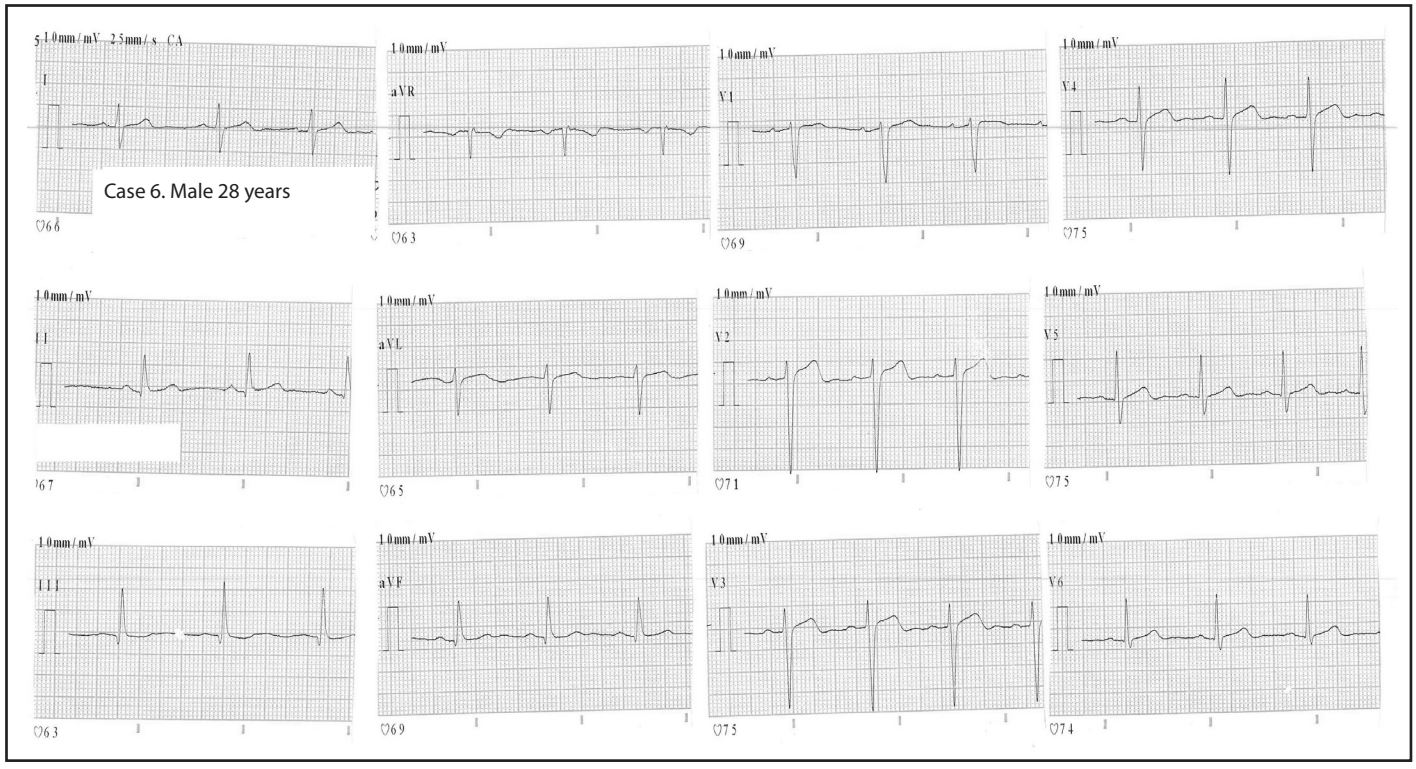

Figure 6. Electrocardiogram case 9. Sinus rhythm, Heart Rate: 66 per minute, electrical axis +15º, Non-specific inferior wall repolarisation disorder, Testosterone decanoate 100mg/week, Intramuscular, 130 minutes of strength training.

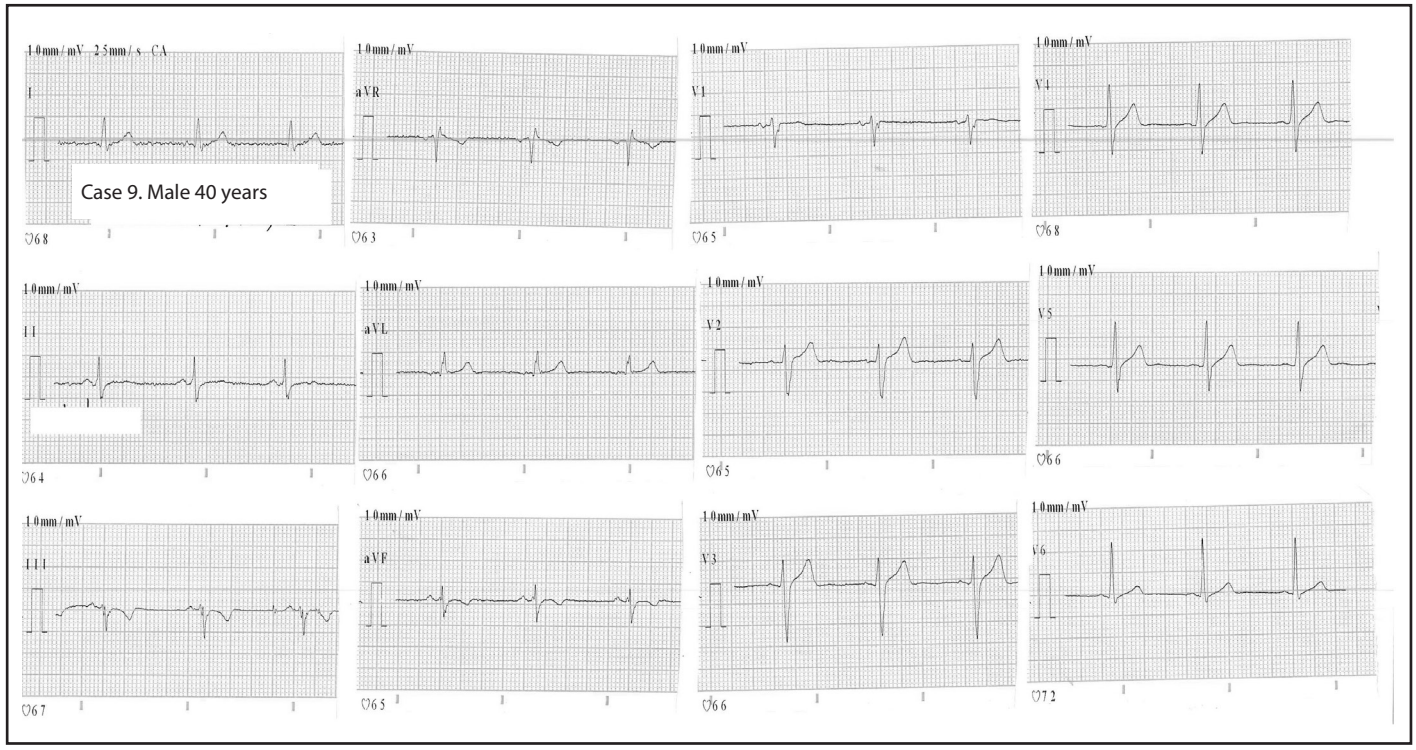

image were identified in this study. Growing concerns over physical fitness have led to a significant increase in the number of people who use AAS to enhance their athletic performance and change their appearance. However, the use of many of these substances is restricted in several countries and, in the case of Colombia and other Latin American countries, the regulations that govern them are limited. This has enabled the emergence of a black market for the commercialisation and consumption of these substances, usually without medical supervision, leading to a neglected public health problem[19].

Various significant electrocardiographic abnormalities were identified in this study. Seven participants (30.4%) presented serious findings, which included anterior T-wave inversion, left bundle branch block and prolongation of the QT interval, while over 50% presented changes considered to be borderline, such as electrical axis deviations and minor alterations to QRS voltage. These results reflect a potential link between the use of AAS and changes to cardiac function, which could increase the risk of arrhythmia and cardiovascular complications in this population. It was also found that the average period of using these substances was 2.8 years, with at least two cycles per year. The majority of participants were engaged in strength training (52.17%) and were men, with an average of 171.2 minutes of training per week. Sagoe, *et al.*[3] reported that the global prevalence of AAS use is 3.3%, this being higher in men (6.4%) when compared to women (1.6%)[3]. Furthermore, Hauger, *et al.* and Vaskinn, et al. reported average consumer ages of approximately 37.1 years[19], with 33.2 in men and 28.7 in women, respectively[20]. These results are similar to those found in this study, in which only one woman took part.

In terms of dosage, the doses reported in this study extensively surpassed the therapeutic recommendations. Testosterone decanoate, for example, the recommended medical use of which is 100-200 mg every 2-4 weeks, was consumed in doses of 100 mg per week[21]. Furthermore, use was observed of such substances as methandrostenolone (Dianabol), the therapeutic use of which - albeit rare - is limited to 5-15 mg per day, whereas the participants reported up to 150 mg per week. Boldenone undecylenate, a steroid for veterinary use, was consumed in doses of 400 mg per week, when the recommended doses in animals are usually far lower and adjusted to weight[21]. This use of medicines of veterinary origin raises additional concerns due to the lack of safety standards or approval in humans[22].

Despite these high and prolonged doses, no participant reported use of medication for post-cycle therapy (PCT), a protocol designed to reestablish natural testosterone production and to offset the side effects following a cycle of AAS. The lack of PCT could contribute to prolonged suppression of the hypothalamic–pituitary–gonadal axis, exacerbating the risk of long-term cardiovascular, metabolic and endocrine complications[23].

The findings in this study are consistent with previous literature but also reveal some relevant differences. Maior, *et al.*[24] concluded that there is prolongation of the QT and PR interval before, during and after exhausting physical exercise, in contrast to the results from this study, in which the average of these intervals was adequate; albeit that the ECG was taken from participants at rest. According to Maior, *et al.*[24], there is greater prolongation of the QT interval upon concluding exhausting exercise, leading to greater risk of tachyarrhythmia and sudden death due to a dysregulated sympathetic response[21,22]. Sculthorpe, *et al.*[25,] described the phenomenon of electrical turbulence at the end of the QRS as a way to assess electrophysiological stability. This turbulence represents small areas of heart tissue that tend to depolarise more slowly in the myocardium, leading to late electrical potentials. These changes are related to increased heart muscle mass, left ventricular hypertrophy, fibrosis, increased collagen synthesis and apoptosis[24]. These phenomena seem to be directly tied to the period of consumption[25,26].

Furthermore, the low resting heart rate values found in this study (68.3 beats per minute) are consistent with that reported by Maior, *et al.*[24] and Sculthorpe, *et al.*[25]. However, Júnior, *et al.*[10] assessed autonomic nervous system response before, during and after a 60-minute aerobic exercise session in consumers of AAS, finding average resting heart rate values of 82.8 beats per minute[10]. The findings by Sculthorpe, *et al.*[25], were dependent on autonomic regulation of cardiac function, which reflects a positive or negative adaptation to training, depending on the predominant parasympathetic level of the subject, relating to muscle mass quantity and training level[26].

They also concluded that this is linked to a greater risk of sudden death. There is usually a faster recovery from parasympathetic predominance following exercise in high-performance athletes, which acts as a protective factor against sudden death and certain types of arrhythmias[27]. However, it has been shown that this recovery following physical effort is slower in consumers of AAS, which creates a window of greater risk[28]. Cole, *et al.* believe that this abnormal heart rate response is a predictor of mortality[29].

From among the most important clinical implications, it must be taken into consideration that prolonged consumption of AAS at high doses is also tied to myocardial dysfunction, left ventricular hypertrophy and accelerated coronary artery disease[30]. Baggish, *et al.* mention that there is a reduction in oxygen supply to the myocardium, which is conducive to increased electrophysiological stability due to the altered systolic function observed in consuming subjects[30]. It is possible that partial depolarisation occurs in a group of affected contractile cells, which makes them susceptible to generating ectopic action potentials. In addition, some people may present concomitant changes that compromise the endothelial tissue, caused by dyslipidaemia, high blood pressure, hyperaldosteronism, haemoconcentration and coronary vasospasms. These factors can worsen the prognosis and lead to myocardial ischaemia, which, when added to the electrophysiological changes, significantly increases cardiovascular risk[31,32].

Furthermore, the drugs most strongly linked to electrophysiological complications are testosterone enanthate[33,34] and testosterone cypionate[12,35], which were used by the participants in this study. In addition, the use of these substances has been linked to classic chest pain, which was reported without changes to the ST segment but with high T-waves in all leads, possibly related to vasospasm phenomena[36]. This effect has been tied to chronic periods of consumption (over two years) at high doses

and without medical supervision, which may lead to heart attacks with healthy coronaries. Something similar occurs with the consumption of cocaine, tobacco, alcohol or amphetamines[21]. According to Sogut, *et al.,* the use of AAS is linked to vasospasm, especially in young people, simulating a coronary syndrome at electrocardiographic levels. In this case, it was linked to the use of stanozolol[37].

One advantage of this study was the relevant identification of serious abnormalities and referral of affected participants for medical care, as well as the focus on a growing problem linked to modern-day beauty stereotypes. Nonetheless, it does present certain limitations; such as the small sample size, the lack of analysis under physical exercise conditions and the absence of complementary evidence, such as Holter monitoring or assessment of heart rate variability. Furthermore, no endocrine analyses were conducted. The lack of PCT could reflect a general lack of knowledge about its benefits or an underestimation of the risks associated with prolonged use of these substances.

These limitations make it difficult to generalise the findings but invite future studies with a prospective approach and control groups in order to better understand the safe doses capable of leading to aesthetic and sports results without compromising people's health.

Conclusions

This study identified electrocardiographic abnormalities in consumers of anabolic-androgenic steroids (AAS), showing that more than 50% of participants presented borderline changes such as electrical axis deviations and QRS voltage alterations, while 30.4% showed serious findings that included T-wave inversion, left bundle branch block and prolongation of the QT interval. These results reflect a significant impact on cardiac function as a result of consuming AAS, especially on the conduction and repolarisation system.

Although no significant links were found with specific molecules, the high doses and prolonged use of these substances (which greatly surpassed therapeutic recommendations) could contribute to the development of left ventricular hypertrophy and autonomic dysfunction. These findings highlight the need to implement public policies aimed at regulating access to these substances and to encourage medical supervision, as well as to conduct prospective studies further investigating the links between dose, consumption time and identified cardiovascular alterations.

Conflict of Interest

The authors declare no conflict of interest.

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