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ECG findings in professional rugby players using international screening recommendations

Clíodhna McHugh ,[1,2] Bradley Petek,[2,3] Aubrey J Grant,[2,4] Sarah Gustus,[2] Nicol van Dyk ,[5,6] Karen Hind ,[7] Fiona Wilson ,[1] Meagan Wasfy[2,8]

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[1]Department of Physiotherapy, Trinity College Dublin, Dublin, Ireland
[2]Division of Cardiology, Massachusetts General Hospital, Boston, Massachusetts, USA
[3]Sports Cardiology Program, Oregon Health & Science University Knight Cardiovascular Institute, Portland, Oregon, USA
[4]Cardiovascular Sport & Performance, MedStar Health, Columbia, Maryland, USA
[5]High Performance Unit, Irish Rugby Football Union, Dublin, Ireland
[6]Section Sports Medicine, Faculty of Health Science, University of Pretoria, Pretoria, South Africa
[7]Department of Sport and Exercise Science, Durham University, Durham, UK
[8]Football Player Health Study, Harvard Medical School, Boston, Massachusetts, USA

Correspondence to
Dr Meagan Wasfy;
mwasfy@partners.org

ABSTRACT

Background While World Rugby guidelines do not mandate the inclusion of an electrocardiogram (ECG) for all players, this is required for entry into international rugby competitions. We, therefore, sought to describe sport-specific normative ECG values and evaluate the performance of contemporary athlete ECG guidelines in male and female professional rugby players.

Methods We retrospectively analysed professional rugby players' ECGs (n=356, male 79%) obtained during preparticipation screening (2010–2022), comparing by sex and playing position (forwards vs backs). ECGs were categorised as normal 'training-related', borderline and abnormal findings, as defined by the 2017 International Recommendations.

Results 84% of players had one or more normal, 'training-related' findings, with males having a higher prevalence than females (91% vs 60%, p<0.001). Most ECG findings did not vary by position. No female player had borderline or abnormal ECG findings. Borderline findings were present in 3% (n=12/356) of players. Abnormal findings were present in 2% (n=7/356) of players. Overall, 2.2% of ECGs were 'positive' (n=8/356, including n=1 ECG with two borderline findings).

Conclusions The application of contemporary ECG interpretation criteria resulted in a low positivity rate isolated to male players. These results help inform the logistic feasibility of ECG-inclusive screening, which is already required to enter major tournaments.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The 2017 'International Recommendations for ECG Interpretation in Athletes' have improved the specificity without compromising the sensitivity of ECG-inclusive screening in athletes.

WHAT THIS STUDY ADDS

⇒ Rugby players have a high prevalence of normal, training-related ECG findings but a very low prevalence of abnormal findings, with an overall positivity rate of 2.2%.

⇒ Our results provide normative ECG findings, which is important given ECG is already a required screening test for several large tournaments regulated by World Rugby.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Findings reassure that ECG-inclusive screening in rugby players using contemporary ECG criteria will not result in a high burden of downstream testing.

⇒ Future work that includes imaging and outcome data is needed to define the overall sensitivity and specificity of ECG-inclusive screening in rugby players.

INTRODUCTION

ECG-inclusive preparticipation athlete screening has become commonplace among professional sports. While World Rugby does not mandate ECG-inclusive screening in all athletes, an ECG is mandated as an entry requirement for World Rugby-controlled and managed tournaments, such as the Rugby World Cup and Sevens World Series,[1] making it a requirement for many high-level players. For other players at the national and international levels, World Rugby suggests an ECG 'if logistically possible' and recommends that if performed, it 'be interpreted by a medical practitioner experienced in reading sports ECGs'.[1] This language reflects a potential pitfall of ECG-inclusive screening. Specifically, there is potential for normal, physiological features in the ECG, which are common manifestations of the well-conditioned heart of an elite athlete, to be misclassified as abnormal by untrained readers,[2 3] resulting in unacceptably high false-positive rates.

The 2017 'International Recommendations for ECG Interpretation in Athletes'[4] reflects an iterative improvement on prior guidelines and has improved the specificity without compromising the sensitivity of ECG-inclusive screening in athletes participating in many different sporting disciplines.[5–8] While the ECG characteristics of several major sports disciplines, including American football,[9–11] soccer,[7 12] basketball[13] and endurance athletes,[14–16] have been thoroughly evaluated, those of rugby players have not previously been evaluated using the International Recommendations. Prior data do not include

a sizeable representation of female contact sport athletes, despite the important impact of sport type and sex on the ECG manifestations of exercise-induced cardiac remodelling.[17 18] We therefore sought to describe sport-specific normative ECG values and evaluate the performance of contemporary athlete ECG guidelines in male and female professional rugby players. A secondary goal of this study was to examine differences in ECGs based on rugby playing position, given the different physiological demands of the forward versus back roles.

METHODS

Study design and participants

The ECGs of professional rugby players obtained during preparticipation screening (2010–2022) from all teams within one European country were retrospectively analysed, compared by sex and by playing position (forwards vs backs). Informed consent was obtained from participants during preparticipation screening over consecutive years from all players to permit retrospective analysis of these clinically obtained ECGs for research purposes.

ECG acquisition and analysis

ECGs were performed using standard 12-lead placement and equipment (MAC 3500; GE Healthcare, Milwaukee, Wisconsin). ECGs were conducted by a skilled clinical nurse and overseen by each team's medical doctor.

For this analysis, ECGs were interpreted by two independent reviewers, one sports cardiologist and the other an exercise scientist. In the event of disagreement, the final interpretation was decided by a third reviewer, a sports cardiologist. ECG features were categorised as normal 'training-related' findings, borderline findings and abnormal findings, as defined by the 2017 International Recommendations.[4]

QRS wave amplitudes and the magnitudes of early repolarisation were measured manually using callipers. Voltage criteria were defined using the Sokolow-Lyon Index for left ventricular hypertrophy (LVH) (S wave in V1+R wave in V5 or V6 ≥35 mm) and right ventricular hypertrophy (R wave in V1+S wave in V5 or V6 >10.5 mm).[19]

Statistical analysis

Statistical analyses were performed using SPSS software (V.22; SPSS). Assumptions of normality were made using the Shapiro-Wilk test (>0.05). Continuous data were compared using independent samples t-test (parametric) or Mann-Whitney U test (non-parametric) and are expressed as mean±SD or median and IQRs. Dichotomous data were compared using Fisher's exact test and are expressed as numbers (per cent). A two-tailed p≤0.05 was defined as statistically significant.

RESULTS

Participant characteristics are presented in table 1. Data from 356 players (79% male, 23±9 years and 94% Caucasian) were analysed. By playing position, 52% of males and 47% of females were forwards.

Table 1 Participant characteristics

	All (n=356)	Males (n=281)	Females (n=75)
Demographics			
Age, years	23 (9)	22 (8)*	26 (8)
Ethnicity, n (%)			
White	335 (94)	263 (94)	72 (96)
Black	15 (4)	12 (4)	3 (4)
Polynesian	6 (2)	6 (2)	–
Playing position, n (%)			
Position, forward	180 (51)	145 (52)	35 (47)
Anthropometrics			
Height, cm	183 (10)	187 (10)*	168 (10)
Weight, kg	97 (23)	100 (20)*	68 (9)
BMI, kg/m^2	27.5 (4.2)	28.3 (3.8)*	24.7 (2.5)
Systolic BP, mm Hg	130 (12)	130 (12)*	127±9
Diastolic BP, mm Hg	71 (15)	70 (15)*	73±9

Data are presented as mean±SD or median (IQR).
*P≤0.05 for males and females.
BMI, body mass index; BP, blood pressure.

Most players had at least one training-related ECG finding (n=300, 84%), with 51% (n=180) demonstrating two or more findings. Normal early repolarisation (NER) and sinus bradycardia were the most common training-related findings (55% and 47%, respectively). Males had a greater prevalence of NER (66% vs 9%, p<0.001), LVH (29% vs 9%, p<0.001), sinus arrhythmia (20% vs 4%, p<0.001) and first-degree atrioventricular block (11% vs 3%, p=0.025) compared with females. All remaining training-related ECG findings were isolated to males (table 2). Female rugby players were significantly more likely to have no notable ECG findings compared with male rugby players (40% vs 9%, p<0.001). Backs for males and females had a higher prevalence of NER (73% vs 60%, p=0.03) and sinus bradycardia (65% vs 37%, p=0.02) than their forward counterparts, respectively (table 2).

Borderline ECG findings were present in 3% (n=12/356) and only in males. For males, 4% (n=11/281) had a single borderline finding, with left atrial enlargement (LAE) (n=7) and right axis deviation (n=3) being the most common. One male (0.4%) demonstrated two borderline findings, LAE and right atrial enlargement, which is considered an abnormal 'positive' ECG.

Abnormal ECG findings were present in 2% (n=7/356) and only in males. For males, 2% (n=6/281) had the presence of a singular abnormal finding, including an intraventricular conduction delay with QRS ≥140 ms (n=3), prolonged QTc (n=2) and anterior T wave

Table 2 Presence of ECG findings by sex and position

	Males			Females		
	All (n=281)	Forwards (n=145)	Backs (n=136)	All (n=75)	Forwards (n=35)	Backs (n=40)
Normal, training-related findings						
Normal early repolarisation	186 (66)	87 (60)	99 (73)*	7 (9)†	2 (6)	5 (13)
Left ventricular hypertrophy	80 (29)	42 (29)	38 (28)	7 (9)†	3 (9)	4 (10)
Right ventricular hypertrophy	18 (6)	7 (5)	11 (8)	–	–	–
Incomplete right bundle branch block	31 (11)	15 (10)	16 (12)	–	–	–
Sinus bradycardia	130 (46)	64 (44)	66 (49)	39 (52)	13 (37)	26 (65)‡
Sinus arrhythmia	57 (20)	30 (21)	27 (20)	3 (4)†	2 (6)	1 (3)
Ectopic atrial pacemaker	3 (1)	–	3 (2.2)	–	–	–
First-degree atrioventricular block	31 (11)	17 (12)	14 (10)	2 (3)†	1 (3)	1 (3)
Mobitz I atrioventricular block	2 (0.7)	–	1 (1.5)	–	–	–
Borderline findings						
Left axis deviation	1 (0.4)	–	1 (0.7)	–	–	–
Right axis deviation	3 (1)	2 (1)	1 (0.7)	–	–	–
Left atrial enlargement	7 (3)	5 (3)	2 (2)	–	–	–
Right atrial enlargement	1 (0.4)	1 (0.7)	–	–	–	–
Right bundle branch block	1 (0.4)	1 (0.7)	–	–	–	–
Abnormal findings						
Intraventricular conduction delay, QRS≥140 ms	3 (1)	3 (2)	–	–	–	–
ST depression, lateral	1 (0.4)	–	1 (0.7)	–	–	–
T wave inversion, lateral	1 (0.4)	–	1 (0.7)	–	–	–
T wave inversion, anterior	1 (0.4)		1 (0.7)			
Prolonged QT	2 (0.7)	2 (1)	–	–	–	–

Data are presented as n (%).
Comparisons are determined by Fisher's exact test.
*P<0.05 between male forwards and backs.
†P<0.05 between males and females.
‡P<0.05 between female forwards and backs.

inversion (TWI) in V3–V4 (n=1) (table 2). One male (0.4%) had two abnormal findings, including lateral TWI and lateral ST depression in V5–V6. Applying the International Recommendations criteria led to 2.2% (n=8/356) of ECGs being 'positive'; seven with abnormal findings and one with two borderline findings.

DISCUSSION

This study is the first to evaluate characteristics of ECGs obtained for preparticipation screening in professional rugby players using the 2017 European Society of Cardiology (ESC) 'International Recommendations for ECG Interpretation in Athletes'.[4] Our findings are summarised as follows. Normal, training-related findings were present in most players and were more likely in males, with NER, sinus bradycardia and LVH being most common. The majority of ECG findings did not vary by playing position. Borderline and abnormal ECG findings were rare and were only present in males. The positivity rate for ECG screening was low (2.2%), which is in keeping with that demonstrated in other athlete populations.[5–7] While World Rugby does not mandate ECG-inclusive screening, it is required to enter several large international tournaments, making it a practical requirement for many international and national players. By defining the positivity rate, our findings help inform expected downstream testing of ECG screening for rugby organisations.

A strength of this study is the inclusion of female rugby players. The one existing study focusing on rugby players did not include females,[20] and female contact sports athletes have been under-represented in mixed sport athlete cohorts. Consistent with prior work in female endurance athletes, our findings suggest that female rugby players had a lower prevalence of many normal training-related features than males. Females did not have a higher prevalence of abnormal anterior TWI compared with males, as others have reported, highlighting that this particular pattern may arise more often in screening female endurance sports and younger athletes.[21]

When considering the feasibility of ECG-inclusive screening, the rate of screening positivity is critically important. An 'abnormal' ECG necessitates further clinical investigation for pathological cardiovascular disorders, which requires additional resources, time and expertise in what constitutes normal findings on cardiac testing for athletes. Our findings of a low positivity rate in rugby players (2.2%), similar to that which has been reported in other sports cohorts (~1–2%),[5–7] help provide reassurance that ECG-inclusive screening in rugby players using contemporary ECG criteria will not result in a high burden of downstream testing. This is particularly relevant given the practical approach that World Rugby has outlined in its guidelines. It highlights the importance of appropriate expertise in athlete ECG interpretation should organisations elect to offer ECG-inclusive screening.[1]

Our study has several important limitations. We evaluated professional rugby players from one country; thus, ECG characteristics from players at different career stages and competition levels may differ. While our study includes a large cohort of rugby players, it is dominated by males and Caucasian players. Therefore, findings of low positivity rates using contemporary ECG criteria may not be generalisable to females and rugby players from different racial/ethnic populations. Notably, this study is the first to include a sizeable number of females. This study was not designed to investigate cardiac structural and functional correlates of the observed ECG findings or to engage players in longitudinal follow-up. Therefore, we cannot define diagnostic performance of the ECG in this population beyond the positivity rate. Future work that includes imaging and outcome data is needed to define the overall sensitivity and specificity of ECG-inclusive screening in this population.

CONCLUSIONS

Our results reassure that ECG-inclusive screening in rugby players using contemporary ECG criteria will not result in a high burden of downstream testing. The normative findings may prove valuable when interpreting ECGs because ECGs are already a required screening test for several large tournaments regulated by World Rugby.

X Clíodhna McHugh @climchugh, Nicol van Dyk @nicolvandyk and Fiona Wilson @fionawilsonf

Contributors CM, MW, KH and FW contributed to the conception and design of the work. CM, NvD, AJG, BP, SG and MW contributed to the acquisition, analysis or interpretation of data for the work. CM and MW drafted the manuscript. CM, BP, NvD and MW critically revised the manuscript. CM and MW gave final approval and agree to be accountable for all aspects of the work ensuring integrity and accuracy.

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Competing interests None declared.

Patient consent for publication Consent obtained directly from patient(s)

Ethics approval This study involves human participants and was approved by the research ethics committee from Trinity College Dublin (Ref 211102) in collaboration with the Rugby National Governing Body.

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ORCID iDs
Clíodhna McHugh http://orcid.org/0000-0001-9960-1954
Nicol van Dyk http://orcid.org/0000-0002-0724-5997
Karen Hind http://orcid.org/0000-0002-4546-5536
Fiona Wilson http://orcid.org/0000-0002-0292-1087

REFERENCES

1 World rugby. Player welfare guidelines: cardiac screening guideline. 2010. Available: https://playerwelfare.worldrugby.org/?documentid=4 [Accessed 20 Oct 2023].
2 Dhutia H, Malhotra A, Yeo TJ, *et al*. Inter-Rater Reliability and downstream financial implications of electrocardiography screening in young athletes. *Circ Cardiovasc Qual Outcomes* 2017;10:e003306.
3 Torabi AJ, Nahhas OD, Dunn RE, *et al*. Athlete ECG T-wave abnormality interpretation patterns by non-experts. *American Heart Journal Plus: Cardiology Research and Practice* 2022;17:100153.
4 Sharma S, Drezner JA, Baggish A, *et al*. International recommendations for electrocardiographic interpretation in athletes. *J Am Coll Cardiol* 2017;69:1057–75.
5 Hyde N, Prutkin JM, Drezner JA. Electrocardiogram interpretation in NCAA athletes: comparison of the 'Seattle' and 'International' criteria. *J Electrocardiol* 2019;56:81–4.
6 Conway JJ, Krystofiak J, Quirolgico K, *et al*. Evaluation of a Preparticipation cardiovascular screening program among 1,686 national collegiate athletic Association division I athletes: comparison of the Seattle, refined, and international electrocardiogram screening criteria. *Clin J Sport Med* 2022;32:306–12.
7 Malhotra A, Dhutia H, Yeo T-J, *et al*. Accuracy of the 2017 International recommendations for Clinicians who interpret adolescent athletes' ECGs: a cohort study of 11 168 British white and black soccer players. *Br J Sports Med* 2020;54:739–45.
8 Dhutia H, Malhotra A, Finocchiaro G, *et al*. Impact of the International recommendations for electrocardiographic interpretation on cardiovascular screening in young athletes. *J Am Coll Cardiol* 2017;70:805–7.
9 Baggish AL, Hutter Jr AM, Wang F, et al. Cardiovascular screening in college athletes with and without electrocardiography: a cross-sectional study. *Ann Intern Med* 2010;152:269.
10 Magalski A, McCoy M, Zabel M, *et al*. Cardiovascular screening with electrocardiography and echocardiography in collegiate athletes. *Am J Med* 2011;124:511–8.
11 Choo JK, Abernethy WB III, Hutter AM Jr. Electrocardiographic observations in professional football players. *The American Journal of Cardiology* 2002;90:198–200.
12 Churchill TW, Petek BJ, Wasfy MM, *et al*. Cardiac structure and function in elite female and male soccer players. *JAMA Cardiol* 2021;6:316–25.
13 Waase MP, Mutharasan RK, Whang W, *et al*. Electrocardiographic findings in national basketball Association athletes. *JAMA Cardiol* 2018;3:69–74.
14 Wilson MG, Chatard JC, Carre F, *et al*. Prevalence of electrocardiographic abnormalities in West-Asian and African male athletes. *Br J Sports Med* 2012;46:341–7.
15 Brosnan M, La Gerche A, Kalman J, *et al*. Comparison of frequency of significant electrocardiographic abnormalities in endurance versus Nonendurance athletes. *Am J Cardiol* 2014;113:1567–73.
16 Wasfy MM, DeLuca J, Wang F, *et al*. ECG findings in competitive rowers: normative data and the prevalence of abnormalities using contemporary screening recommendations. *Br J Sports Med* 2015;49:200–6.
17 Finocchiaro G, Sharma S. Do endurance sports affect female hearts differently to male hearts *Future Cardiol* 2016;12:105–8.
18 Barbier J, Ville N, Kervio G, *et al*. Sports-specific features of athlete's heart and their relation to echocardiographic parameters. *Herz* 2006;31:531–43.
19 SOKOLOW M, LYON TP. The ventricular complex in left ventricular hypertrophy as obtained by Unipolar Precordial and limb leads. *Am Heart J* 1949;37:161–86.

20 Chevalier L, Kervio G, Corneloup L, *et al*. Athlete's heart patterns in elite Rugby players: effects of training Specificities. *Arch Cardiovasc Dis* 2013;106:72–8.

21 Malhotra A, Dhutia H, Gati S, *et al*. Anterior T-wave inversion in young white athletes and Nonathletes: prevalence and significance. *J Am Coll Cardiol* 2017;69:1–9.

Correction: *ECG findings in professional rugby players using international screening recommendations*

McHugh C, Petek B, Grant AJ, *et al*. ECG findings in professional rugby players using international screening recommendations. *BMJ Open Sp Ex Med* 2024;10:e001813. doi: 10.1136/bmjsem-2023-001813

The article has undergone revisions subsequent to its online publication. The authors wish to alert readers to certain textual inaccuracies in their manuscript, which have since been rectified.

The mistake occurred within the Methods section, specifically under the subheading 'Study design and participants'. The corrected text should have been as follows:

The ECGs of professional rugby players obtained during preparticipation screening (2010–2022) from all teams within one European country were retrospectively analysed, compared by sex and by playing position (forwards vs backs). Informed consent was obtained from participants during preparticipation screening over consecutive years from all players to permit retrospective analysis of these clinically obtained ECGs for research purposes.

As a result, the Ethics approval statement has been updated to:

This study involves human participants and was approved by the research ethics committee from Trinity College Dublin (Ref 211102) in collaboration with the Rugby National Governing Body.

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