BJSM Online First, published on November 13, 2014 as 10.1136/bjsports-2014-093857

Cardiovascular evaluation of middle-aged individuals engaged in high-intensity sport activities: implications for workload, yield and economic costs

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Accepted 26 October 2014

ABSTRACT

Background The European Association of Cardiovascular Prevention and Rehabilitation (EACPR) recommends cardiovascular evaluation of middle-aged individuals engaged in sport activities. However, very few data exist concerning the impact of such position stand. We assessed the implications on workload, yield and economic costs of this preventive strategy.

Methods Individuals aged 35–65 years engaged in high-intensity sports were examined following the EACPR protocol. Athletes with abnormal findings or considered at high-cardiovascular risk underwent additional examinations. The costs of the overall evaluation until diagnosis were calculated according to Swiss medical rates.

Results 785 athletes (73% males, 46.8±7.3 years) were enrolled over a 13-month period. Among them, 14.3% required additional examinations: 5.1% because of abnormal ECG, 4.7% due to physical examination, 4.1% because of high-cardiovascular risk and 1.6% due to medical history. A new cardiovascular abnormality was established in 2.8% of athletes, severe hypercholesterolaemia in 1% and type 2 diabetes in 0.1%. Three (0.4%) athletes were considered ineligible for high-intensity sports, all of them discovered through an abnormal ECG. No athlete was diagnosed with significant coronary artery disease on the basis of a high-risk profile or an exercise ECG. The cost was US$199 per athlete and US $5052 per new finding.

Conclusions Cardiovascular evaluation of middle-aged athletes detected a new cardiovascular abnormality in about 3% of participants and a high-cardiovascular risk profile in about 4%. Some of these warranted exclusion of the athlete from high-intensity sport. The overall evaluation seems to be feasible at reasonable costs.

INTRODUCTION

Regular aerobic exercise at moderate intensity reduces cardiovascular morbidity and mortality,[1] while acute vigorous physical exertion may trigger adverse cardiovascular events in the presence of underlying heart diseases, particularly in low fitness participants.[2] Sudden cardiac death during physical activity is rare but the incidence raises substantially with athlete's age[3 4] and the majority of cardiac events in adults are due to atherosclerotic coronary artery disease (CAD).[2 4] Cardiac evaluation may thus play a pivotal role in detecting asymptomatic individuals affected by heart diseases, contributing to minimise risks during sport.

The European Association of Cardiovascular Prevention and Rehabilitation (EACPR) has recently published recommendations on cardiovascular evaluation of middle-aged individuals participating in recreational or competitive sporting activities. According to such position stand, a prespecified protocol of medical screening should be performed among participants engaged in high-intensity sports.[5] The main focus is to detect asymptomatic athletes with CAD through an exercise ECG in participants at increased risk. A similar approach has been suggested by the American Heart Association (AHA) and the American College of Sports Medicine (ACSM).[6–8]

However, cardiovascular evaluation of middle-aged athletes still represents a clinical challenge, due to the lack of scientific evidence on its utility and efficacy and because there are large numbers of individuals playing sport. Few data exist on the results of implementing such a strategy.[9] Therefore, the aim of our study was to assess implications for workload (subsequent examinations generated), efficacy (detection rate) and economic costs of a cardiovascular examination of middle-aged individuals engaged in high-intensity sports, following the protocol proposed by the EACPR.[5]

METHODS

Design

The current prospective, observational and multicenter study was performed in three Swiss public institutions: the Division of Cardiology of the Hospital of Bellinzona, the Center for Sports Medicine of the Hospital of Locarno and the Division of Cardiology of the Hospital of Lugano. The study duration was 13 months, from January 2013 through January 2014. Study participants were self-referred and recruited through sports clubs, competitive and amateur sporting events. The study conforms to the principles stated in the Declaration of Helsinki and was approved by the Scientific Ethics Committee of Canton Ticino.

Study population

We included middle-aged individuals aged 35–65 years who engaged in high-intensity sports (>6 metabolic equivalents or METS)[5] for more than 2 h per week. High-intensity sports included running, cycling, triathlon, football, swimming, tennis, climbing, cross-country skiing, etc.[10] Exclusion criteria were participants with known cardiovascular diseases (systemic hypertension was

To cite: Menafoglio A, Di Valentino M, Porretta AP, *et al*. *Br J Sports Med* Published Online First: [*please include* Day Month Year] doi:10.1136/bjsports-2014-093857

not considered an exclusion criterion) or who had already underwent a cardiac examination for screening purpose or because of symptoms in the previous year. A written informed consent was signed by each athlete.

Examination protocol

Participants were examined following the EACPR recommendations for individuals engaged in high-intensity sport activities. The protocol included personal and family history, physical examination, ECG and estimation of the individual cardiovascular risk using the Systematic Coronary Risk Evaluation (SCORE) chart.[5] Since there are no specific recommendations for the clinical assessment in adult athletes, we applied the clinical examination criteria proposed in the 2005 European Society of Cardiology consensus on cardiovascular preparticipation screening in young athletes.[11] The ECG was printed out as hard copy (25 mm/s, 1 mV/cm) and interpreted based on the 'Seattle Criteria' for interpreting ECG in young athletes,[12–15] due to the lack for specific adult athlete criteria. Blood samples were collected from each participant in order to evaluate the total cholesterol (Accutrend Plus, Roche Diagnostics, Mannheim, Germany) and glucose level (Contour XT, Bayer, Basel, Switzerland). We then calculated the individual cardiovascular risk according to the SCORE chart. The SCORE chart allows to estimate the absolute risk of atherosclerotic cardiovascular death within 10 years based on gender, age, total cholesterol level, systolic blood pressure and smoking status.[16] We applied the SCORE chart for Switzerland, a low-risk country.[16] For participants with already treated hypertension or hypercholesterolaemia, the blood pressure/cholesterol value assessed on the screening day was considered in the SCORE chart. Former smokers who stopped smoking more than 5 years before were considered as non-smokers. High-risk profile was defined by a ≥5% 10-year risk in the SCORE chart or by a markedly raised single cardiovascular risk factor, this latter represented by: a >8 mmol/L (310 mg/dL) blood total cholesterol irrespective of treatment, a >180/110 mm Hg systemic hypertension irrespective of treatment, diabetes mellitus (including individuals already known for diabetes or newly diagnosed diabetes defined as fasting blood glucose ≥7.0 mmol/L—126 mg/dL—or postprandial blood glucose ≥11.1 mmol/L—200 mg/dL—more than once) or strong family history of premature (below 50 years) cardiovascular diseases in first-degree relatives.[5]

Individuals with abnormal history, physical examination, ECG or with a high-risk profile underwent further examinations to confirm or exclude an underlying cardiac disease, according to the recommendations for evaluation of athletes with cardiovascular abnormalities.[17 18] In case of high-risk profile, the first test recommended was a symptom-limited exercise ECG which, if positive, was followed by additional evaluations.[5] The screening phase was performed by cardiologists in Bellinzona and Lugano (67.1% and 11.4% of athletes examined, respectively), and by sports physicians in Locarno (21.5% of athletes), all with long-standing clinical experience. ECGs, indications for subsequent examinations and all final diagnoses were consensually read and established by two cardiologists (AM and MDV) with extensive experience in athlete evaluation.

Costs

The screening evaluation (history, physical examination, ECG, blood cholesterol and glucose level) was free of charge for all participants while additional cardiac examinations were financially supported by the health insurances. For each individual, the calculated cost included the screening evaluation and all further examinations performed to reach the final diagnosis, according to the current Swiss medical rates for public hospitals.[19] Treatment and follow-up costs were not calculated. Costs are expressed in US Dollars (US$) for ease of interpretation. They are rounded at unit. The current exchange rate is about SFr1 for US$1.11 and SFr1 for €0.82. According to the Swiss medical system, the costs of cardiac examinations include medical and non-medical personnel, infrastructures and equipment required to carry out the examinations.

Results are expressed as mean±SD.

RESULTS

Study population

Table 1 shows the characteristics of the study population. A total of 785 consecutive individuals were examined. Running and cycling were the activities most frequently practiced. Despite most individuals were engaged in leisure-time sports, the activity load was consistent with almost 6 h per week. A minority of enrolled participants had previously undergone a cardiac examination and only a small proportion presented with known cardiovascular risk factors.

Abnormal findings and further cardiac evaluations

The screening evaluation was abnormal in 112 individuals (14.3%) who underwent additional examinations: 5.1% due to

Table 1 Population characteristics

Number of athletes, n (%)	785
Males	571 (72.7)
Females	214 (27.3)
Age, years±SD	46.8±7.3
Ethnicity, n (%)	
Caucasian	783 (99.7)
Asian	2 (0.3)
Body mass index±SD	23.7±2.7
Heart rate, bpm±SD	62±10
Systolic blood pressure, mm Hg±SD	126±14
Diastolic blood pressure, mm Hg±SD	81±9
Sport, n (%)	
Running	262 (33.4)
Cycling	186 (23.7)
Football	56 (7.1)
Climbing	38 (4.8)
Triathlon	35 (4.4)
Other	208 (26.6)
Mean weekly training hours±SD	5.7±4.1
Years of practice±SD	20.0±14.5
Level of competition, n (%)	
Amateurs	547 (69.7)
Regional	186 (23.7)
National	36 (4.6)
International	16 (2.0)
Previous cardiac examination, n (%)	
Screening	92 (11.7)
Symptoms	23 (2.9)
Known cardiovascular risk factors, n (%)	
Hyperlipidaemia under treatment	22 (2.8)
Hypertension under treatment	28 (3.6)
Smokers: current	58 (7.4)
former	94 (12.0)
Diabetes mellitus	4 (0.5)
Strong premature family history	11 (1.4)

pathological ECG findings, 4.7% because of abnormal physical examination, 1.6% due to positive personal or family history and 4.1% following a high-risk profile (selected athletes had more than one pathological criterion). A markedly raised major cardiovascular risk factor represented the most frequent reason of high-cardiovascular risk instead of a ≥5 SCORE. Table 2 details the abnormal findings and the corresponding additional tests performed. In selected cases, several examinations were additionally carried out depending on the clinical circumstances. Table 3 summarises second-line cardiac examinations performed and their relative costs.

New cardiac diagnosis and clinical implication

A new cardiovascular disease was detected in 22 individuals (2.8%). Table 4 shows their clinical characteristics including performed examinations, therapy and decision about sport eligibility. The majority of them (17/22) were detected because of an abnormal physical examination and systemic hypertension as well as valvular diseases were the most frequent diagnoses. One athlete with severe hypertension was immediately treated with medication. Valvular diseases were all of mild or mild-to-moderate degree and compatible with sport activities. ECG allowed to establish a new cardiac diagnosis in four individuals: one had an asymptomatic intermittent Wolff-Parkinson-White ECG-pattern and was conservatively treated because at low risk, while the other 3 (0.4%) had a cardiac disease precluding high-intensity sport. A 38-year-old cross-country skier competing at regional level had deep negative T-waves and a final diagnosis of apical hypertrophic cardiomyopathy. A 54-year-old runner competing at regional level had pathological Q-waves and was diagnosed with an old asymptomatic myocardial infarction associated to stress-induced ventricular arrhythmia, for which he was treated with aspirin, statins and β-blockers. A 46-year-old amateur boxer had minor T-waves inversion and the echocardiogram accidentally demonstrated a 50 mm aneurysm of the ascending aorta. Importantly, all athletes ineligible for sport due to cardiac disease were discovered only through an abnormal ECG.

Besides cardiac diseases, the screening examination allowed to point out 8 individuals (1.0%) with severe hypercholesterolaemia (>8 mmol/L—310 mg/dL) and 1 athlete (0.1%) with type 2 diabetes mellitus. One of the individuals with hypercholesterolaemia was immediately pharmacologically treated because of concomitant risk factors. The athlete with diabetes mellitus was initially treated with an appropriate diet.

Table 2 Abnormal findings (history, physical examination, ECG and high-risk profile) in the study population and tests required for each abnormality

Abnormal finding	Number of participants (%)	Test for each abnormality
Family history		
Hypertrophic cardiomyopathy	1 (0.1)	E
Personal history	12 (1.5)	
Atypical angina	8 (1.0)	Ex
Palpitations	2 (0.3)	E, Ex, H
Dyspnoea	1 (0.1)	E, Ex
Syncope of undetermined origin	1 (0.1)	E, Ex, H
Physical examination	37 (4.7)	
Cardiac auscultation	24 (3.1)	E
Hypertension	14 (1.8)	BPM
ECG	40 (5.1)	
Negative T-waves	12 (1.5)	E, Ex
ST-segment depression	4 (0.5)	E, Ex
Left axis deviation	9 (1.1)	E
Complete RBBB	6 (0.8)	E, Ex
Abnormal Q-waves	3 (0.4)	E
Ventricular premature beats	3 (0.4)	E, Ex, H
Left atrial enlargement	2 (0.3)	E
Complete LBBB	1 (0.1)	E, Ex
WPW ECG-pattern	1 (0.1)	E, Ex, H
Prolonged QT interval	1 (0.1)	E, Ex, H
Right axis deviation	1 (0.1)	E
High-risk profile	32 (4.1)	
Strong premature family history	11 (1.4)	Ex
SCORE ≥5	9 (1.1)	Ex
Total cholesterol >8 mmol/L	8 (1.0)	Ex
Diabetes mellitus	5 (0.6)	Ex
Blood pressure >180/110 mm/Hg	1 (0.1)	BPM, E, Ex
Total individuals with abnormal findings	112 (14.3)	

Selected athletes had more than one abnormal finding. More tests have been required per abnormal finding depending on the clinical circumstance.
BPM, 24 h blood pressure monitoring; E, echocardiogram, Ex, exercise ECG; H, 24 h Holter monitoring; LBBB, left-bundle branch block; RBBB, right-bundle branch block; SCORE, Systematic Coronary Risk Evaluation; WPW, Wolff-Parkinson-White.

Exercise ECG testing

An exercise ECG was performed in 76 athletes: 32 following high-cardiovascular risk, 29 because of abnormal ECG, 12 due to history and four due to abnormal physical examination (more than one reason in one case). In three cases, the resting ECG was already suggestive for cardiac disease (old myocardial infarction and hypertrophic cardiomyopathy) or uninterpretable for ischaemia (Wolff-Parkinson-White). Among the other 73 athletes, 4 (5.5%) had features of inducible ischaemia (all with normal resting ECG), none had symptoms or other pathological findings. These four athletes underwent additional cardiac examinations (stress cardiac MRI in one case, myocardial perfusion scintigraphy in another case, coronary CT in two cases and coronary angiography in one case): no significant CAD was detected. Therefore, no athlete was diagnosed with a significant CAD on the basis of a high-risk profile or an exercise ECG whose false-positive rate was 5.5%.

Table 3 Cardiac examinations performed and relative costs

Exam (cost per exam, US$)	Number of participants (%)	Total cost per test (US$)
Baseline cardiovascular evaluation (130)*	785 (100)	102 050
Exercise ECG (174)	76 (9.7)	13 224
Echocardiogram (346)	71 (9.0)	24 566
24 h blood pressure monitoring (97)	14 (1.8)	1358
24 h Holter monitoring (217)	12 (1.5)	2604
Stress cardiac MRI (1000)	3 (0.4)	3000
Coronary CT (845)	3 (0.4)	2535
Coronary angiography (2394)	2 (0.3)	4788
Stress myocardial perfusion scintigraphy (1953)	1 (0.1)	1953
Tilt test (309)	1 (0.1)	309
ECG monitoring, 1 week (219)	1 (0.1)	219
Total cost of the programme		156 606

*The cost of the baseline cardiovascular evaluation includes history taking (US$37), cardiovascular clinical examination (US$47), ECG (US$30) and blood cholesterol and glucose level (US$16).

Table 4 Individuals with a new cardiac diagnosis: clinical characteristics

Number	Diagnosis	Sex	Age, range (Y)	Symptoms	Abnormal finding at screening exam	Examination	Therapy	Eligibility for sport
8	HTA	8 M	40–54	N	PE (HTA)	8 BPM, 5 E, 2 Ex	1: drugs	Y
5	MVP, MR 2+: 3, MR 2–3+: 2	3 M, 2F	42–55	N	PE (clic, murmur)	5 E, 2Ex, 1H	N	Y
3	BAV, AR 2+: 2, mild AS: 1	3 M	43–62	N	PE (clic, murmur)	3 E, 1 Ex	N	Y
1	mild PS	M	54	N	PE (murmur)	E	N	Y
1	VVS	M	39	Y	Hy	E, Ex, H, TT, Mo	N	Y
1	WPW	M	48	N	ECG	E, Ex, H	N	Y
1	HCM	M	38	N	ECG	E, CRM, Ex, H	N	N
1	CHD, old MI	M	54	N	ECG	E, Ex, H, CRM, CA	Y, drugs	N
1	AAA, 50 mm	M	46	N	ECG	E, Ex	N	N

AAA, aneurysm of the ascending aorta; AR 2+, mild aortic regurgitation; AS, aortic stenosis; BAV, bicuspid aortic valve; BPM, 24 h blood pressure monitoring; CA, coronary angiography; CHD, coronary artery disease; CRM, cardiac MRI; E, echocardiogram; Ex, exercise ECG; F, female; H, 24 h Holter monitoring; HCM, hypertrophic cardiomyopathy; HTA, systemic hypertension; Hy, history; M, male; MI, myocardial infarction; MR 2+, mild mitral regurgitation; MR 2–3+, mild to moderate mitral regurgitation; MVP, mitral valve prolapse; N, no; PE, physical examination; PS, pulmonary stenosis; TT, tilt-test; Mo, ECG monitoring 1 week; VVS, vaso-vagal syncope; WPW, Wolff-Parkinson-White; Y, yes.

Costs

For 85.7% of individuals (those without abnormal findings at the screening examination and not at high risk), the cost was only that of the baseline cardiovascular evaluation, namely US $130. The costs for the remaining athletes varied depending on the additional investigations performed (Table 3): the highest cost was attributable to the athlete diagnosed with an old myocardial infarction (US$4272). The costs was US$156 606 for the overall screening programme, US$199 per athlete, US$5052 per new finding and US$52 202 per new finding precluding high-intensity sport.

DISCUSSION

The current study assessed implications for workload (the number of additional tests that would be generated), yield and costs of a cardiovascular evaluation in middle-aged individuals engaged in high-intensity sports, following the protocol endorsed by the EACPR. We found that: (1) a new cardiovascular abnormality was discovered in about 3% of athletes and a high-cardiovascular risk profile in about 4%, (2) rarely, these abnormalities precluded intense physical activity, (3) the ECG has an important role in detecting serious cardiac diseases, (4) no individual was diagnosed with CAD on the basis of a high-risk profile or an exercise ECG, (5) the costs of the evaluation seem reasonable.

To date, only one study evaluated the implications of a cardiovascular screening in adult athletes. Aagaard *et al*[9] studied 153 long-distance runners (all men) following the EACPR proposal, adding however for everyone an echocardiogram and blood laboratory studies. Therefore, our study was the first to prospectively investigate the implications of cardiovascular screening in a relatively large cohort of adult athletes (785), strictly following the EACPR recommendations.

About 1 in 7 of the athletes in our study (14.3%) required additional examinations due to abnormal findings. This proportion was greater than what estimated in Aagaard's study (9%),[9] but data are not comparable due to the systematic inclusion of an echocardiogram in Aagaard's protocol. Similarly, the proportion of adult athletes requiring additional examinations surpasses the young athlete one (accounting for 5–10% of the young athlete screened population),[20–23] mostly due to the major concern represented by CAD among an older population.[5]

In the present study, a new cardiac diagnosis was established in 2.8% of athletes (5.9% in Aagaard's series[9]). The most frequent diagnoses were represented by systemic hypertension (1%) and mild valvular heart diseases (1.1%), both detected through an abnormal physical examination. Besides cardiac pathologies, a significant number of major cardiovascular risk factors was pointed out including severe hypercholesterolaemia in 1% and diabetes mellitus in 0.1% of participants, therefore considered at high-cardiovascular risk profile.

The major goal of screening adult athletes is CAD detection, which represents the most important cause of cardiac events during sport.[2 4] However, we should consider the low prevalence of significant CAD in an asymptomatic low-risk middle-aged population, such as the athlete one, ranging from 0.06% to 1.6%.[24] Exercise ECG is traditionally considered the best available test for screening purpose due to its established prognostic value, widespread availability and low cost.[25] Nevertheless, its limited sensitivity and specificity severely reduce its accuracy for CAD detection among athletes,[25] taking into account the direct relation between test performance and pretest probability. Indeed, observational studies demonstrated an increased risk of cardiac events associated with positive exercise ECG in men with diabetes, advanced age or multiple cardiac risk factors, whereas the prognostic value has not been demonstrated in asymptomatic healthy women.[25] Moreover, no previous study has ever demonstrated the impact on morbidity and mortality of screening CAD in an asymptomatic population.[24 25] On these bases, routine exercise ECG testing before exercise training was not recommended by the US Preventive Services Task Force.[24]

On the other hand, despite the absence of solid scientific evidence, the AHA, the ACSM and the EACPR recommend performing exercise ECG in the subpopulation at higher risk. The definition for such population varies slightly.[5–8] The EACPR identifies the high-risk population by a ≥5% 10-year risk in the SCORE chart or by a markedly raised single cardiovascular risk factor. Following the EACPR model, in our study we found 4.1% of individuals at high-cardiovascular risk and 1.1% were identified through a high SCORE, similarly to Aagaard's data (1.3%).[9] No athlete who performed an additional exercise ECG due to a high risk or for other abnormal findings was diagnosed with a significant CAD, similarly to Aagaard's results.[9] This was anticipated on the basis of the aforementioned considerations. Nevertheless, for individuals with a high-risk profile, appropriate lifestyle interventions and further follow-up examinations were planned.[5] Moreover, we estimated a 5.5% of false-positive

exercise ECG, confirming the results of previous small studies among athletes.[26–28]

ECG is part of the evaluation of middle-aged athletes according to American[7 8] and European[5] recommendations. Considerable efforts have been made so far to develop specific criteria for ECG interpretation among young athletes,[12–15] while no study has ever specifically focused on adult athlete ECG, taking into account the physiological age-related modifications (eg, axis deviation, conduction disturbances)[29] or the age-related and exercise-related QRS voltage changes or ECG changes consistent with prior ischaemic events in an adult athlete. In the present study we applied the recently published 'Seattle Criteria', although they were developed for young athletes and not intended to be used in athletes aged over 35 years. Nevertheless, we demonstrated a rate of abnormal ECGs (5.1%) similar to that in previous studies among young athletes.[23 30–32] Most importantly, the three participants diagnosed with a cardiac disease precluding high-intensity sports (including the single athlete with CAD) were identified only through an abnormal screening ECG. Similarly, in Aagaard's study,[9] the two athletes considered definitively ineligible for sport were diagnosed through ECG (both with long QT syndrome). Such observations confirm the pivotal role of ECG in cardiovascular screening, representing a major tool in the evaluation of adult athletes.

The economic burden always represents an important issue of a screening programme addressed to a high number of individuals. To date, no previous study tried to quantify the economic costs of a cardiac screening examination of middle-aged athletes. Our study first assessed the estimated costs of a cardiovascular evaluation of middle-aged athletes, calculating a reasonable amount of US$199 per athlete and US$5052 per new finding. Compared to our previous study in young athletes where we estimated a cost of US$163 per athlete,[23] the higher cost among adults may be essentially explained by the greater number of additional examinations performed in an older population.

Limitations

There were several limitations in establishing the risk profile according to the SCORE system: (1) we adopted the SCORE chart for Switzerland, a low-risk population, neither considering athlete's original country nor the duration of stay in Switzerland (if the individual was native from a high-risk country), (2) for individuals with already treated hypertension or hyperlipidaemia (a small minority), we considered the blood pressure/cholesterol value assessed on the screening day since we were not able to retrieve pretreatment values, (3) former smokers were considered as non-smokers if they stopped smoking more than 5 years before. It is conceivable that the estimated risk for such specific groups had been underestimated so that fewer athletes underwent an exercise ECG according to the individual risk profile.

We provided a cost analysis of a cardiovascular evaluation of middle-aged athletes not considering, for individuals with abnormal findings, treatment and follow-up costs. Therefore, the societal costs involving the implementation of such a screening programme would certainly be higher.

Our population was almost completely of Caucasian ethnicity. Black athletes have a higher rate of ECG abnormalities (many of which normal variations)[32] potentially increasing the number of downstream tests and costs of the programme. Arab athletes have similar rates of ECG abnormalities as Caucasian athletes.[33] Our results may not be generalisable to more diverse populations aged >35 years.

The ECG was interpreted according to the Seattle criteria which are not intended to be used in older adult athletes (>35 years). This may have potentially missed some cases of ischaemic heart disease.

Finally, the results of our study may not be generalisable to other settings due to the limited simple size and since ECGs, additional examinations and diagnoses were consensually established by two cardiologists highly experienced in athlete evaluation.

CONCLUSIONS

Although the modalities of cardiovascular screening of middle-aged athletes are still a matter of dispute, either the American Associations of Cardiology and Sports Medicine and the European Society of Cardiology recommend a screening evaluation in adult athletes.[5–8] Following the EACPR proposal, we detected about 3% of new cardiovascular diseases and about 4% of individuals at high-cardiovascular risk profile, which warranted excluding some of these athletes from high-intensity sports. In particular, ECG plays a pivotal role, representing an important tool for serious cardiac disease detection. The overall evaluation seems to be feasible at reasonable costs.

What are the new findings?

- Cardiovascular evaluation in middle-aged athletes detects a new cardiovascular abnormality in about 3% of participants and a high-cardiovascular risk profile in about 4%.
- The ECG alone identifies cardiac diseases that should exclude the athlete from high-intensity sport activities.
- No athlete was diagnosed with significant coronary artery disease on the basis of a high-cardiovascular risk profile or an exercise ECG.
- The cardiovascular screening examination seems to be feasible at reasonable costs.

How might it impact on clinical practice in the near future?

- Middle-aged athletes with a high-cardiovascular risk profile identified through screening should be closely followed-up.
- The ECG has a central role in the cardiovascular evaluation of middle-aged athletes.
- Costs should not represent an important limitation to cardiovascular evaluation in middle-aged athletes.

Contributors AM and MDV were responsible for the conception and design of the study. AM conducted the analyses, which were planned and checked with the coauthors. All authors were involved in data collection over the study period. All authors contributed to interpretation of the findings and had full access to all data. AM wrote the first draft of the paper, which was critically revised by MDV, APP and AG. The final manuscript was approved by all authors. AM is the study guarantor.

Funding This study was supported by grants from the Ente Ospedaliero Cantonale Ticinese, Biotronik Swiss, Medtronic Swiss and Astra Zeneca Swiss.

Competing interests None.

Ethics approval Scientific Ethics Committee of Canton Ticino, Switzerland.

Provenance and peer review Not commissioned; externally peer reviewed.

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Br J Sports Med published online November 13, 2014