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CASE REPORT

Common electrocardiogram variations pre- and post-marathon

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Key Clinical Message

Electrocardiographic changes can be present in marathon runners. These findings may be misinterpreted as malignant by healthcare providers. For example, incomplete right bundle branch block, early ventricular repolarization, and left ventricular hypertrophy by voltage criteria alone are quite common in athletes, yet considered benign.

Keywords

Arrhythmia, athlete's heart, electrocardiogram, marathon.

Introduction

A solid foundational knowledge of normal electrocardiogram (ECG) variants is important in clinical practice, particularly in the general practice environment or internal medicine. We sought to evaluate the electrocardiographic effect of marathon running. Few studies have collected and reported pre- and post-race ECG findings, particularly in a group including female and older, so-called, masters-class (40+ years) runners. This is surprising given the major shift in demographic makeup of U.S. marathon finishes over the past 20 years, with female and masters finishers reaching all-time highs in 2013 [1]. In 1995, female runners accounted for only 26% of marathon finishers, while masters-class runners accounted for 41%. This is in stark contrast to 2013 when females and masters-class runners each represented 47% of marathon finishers [1]. These demographic changes along with growth overall in the popularity of marathon running [1] should motivate clinicians not only to better understand the potential deleterious effects of endurance sports [2, 3], but also better appreciate normal and common electrocardiographic findings in endurance athletes across the lifespan. Our results, while not breaking new ground in understanding the physiologic response of the heart to marathon running, can reinforce to the general practice healthcare provider the normal athlete variants common on ECG.

Case Histories

The subjects consisted of 13 female (42.54 ± 12.00 years old) and nine male runners (46.55 ± 13.90 years old) who ran the 2015 Hartford (CT) Marathon. The age distribution of the participants ranged from 22 to 63 years

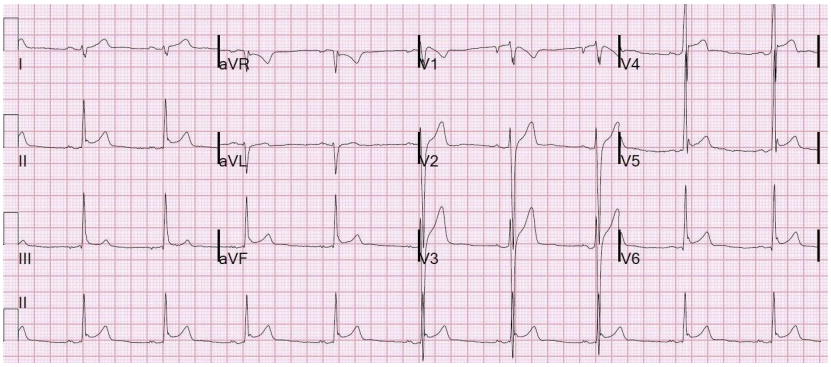

Figure 1. Early ventricular repolarization pattern (ERP).

of age with the following number of subjects recruited from each age range 20–29 (n = 3), 30–39 (n = 5), 40–49 (n = 6), 50-59 (n = 5), and 60–65 (n = 3). For each subject, a standard, resting 12-lead ECG was performed 12 h prerace (baseline) and 20 h postrace. All ECGs were performed and evaluated by the same clinician. In addition, serum cardiac biomarkers (Troponin I and B type Natriuretic Peptide) were measured at the same time points, plus at an intermediate interval, at the conclusion of the marathon.

Outcomes

Ten subjects demonstrated sinus arrhythmia (SA); of these, three had SA present pre- and postmarathon, five subjects had SA prerace but a regular sinus rhythm postrace, and two had the reverse, a prerace normal sinus rhythm with postmarathon sinus arrhythmia. Sinus bradycardia (HR < 60 bpm) was common, befitting a group of aerobically fit runners, but no subject had a resting heart rate below 30 bpm, a clinical marker indicative of pathology. There was no tachycardia. One subject had an ectopic atrial rhythm present at baseline that persisted to their follow-up ECG. Two subjects had slight P wave notching insufficient to be characterized as atrial enlargement by standard criteria and without a change in morphology postrace. An incomplete RBBB, unchanged pre/postrace was revealed in a single participant.

While a number of subjects had Q waves, none were by definition pathologic (>3 mm or >40 msec) and are not considered a significant finding. A single subject demonstrated an ischemic pattern of ST changes, with ST depression of 0.5–1 mm in leads V3–V5 and flattened T waves across the precordium that manifested postmarathon. This was a significant finding, although the subject was entirely asymptomatic and serum biomarkers were not disproportionately elevated. The most common finding, and one present among the majority of participants (16), was early ventricular repolarization pattern (ERP). Typically manifesting with ST elevation, J-point elevation or terminal slurring of the QRS; ERP is generally thought to be a benign process unreflective of an underlying structural abnormality and commonly observed in healthy athletes (Fig. 1) [4]. Ten participants with ERP had the phenomenon present to the same degree pre- and postrace. The six remaining subjects with ERP had more pronounced ERP postrace. No left-axis deviation was observed. In one subject, a right-axis shift prerace normalized postrace. Five of the subjects had isolated voltage criteria for left ventricular hypertrophy (LVH), a normal finding in the athlete, and interestingly, in a study with greater female representation, the five were all males. No PAC's, PVC's, or arrhythmias were appreciated. Age was not strongly correlated with particular types of ECG variants, and isolated LVH was the only characteristic that tended to predominate in one gender compared to another, perhaps owing to differences in the left ventricular muscle mass of men versus women. Finally, no correlations between ECG changes and serum cardiac biomarkers were found.

Discussion

It is established science and commonly understood that exercise is a foundational element for achieving optimal health. Routine physical activity is known to be associated with the prevention and treatment of some of the most prevalent chronic diseases of our time, including heart disease, obesity, various cancers, depression, and diabetes. For those willing and able, regular health-promoting exercise lowers an individual's susceptibility to disability and provides for a longer life expectancy [5]. It is not surprising then, in the United States, participation in marathon running has nearly doubled in the past two decades, reaching an all-time high of approximately 541,000 finishers in 2013 [2]. Despite its popularity, it has been well established that

marathon running places extensive strain on the human body, including the cardiovascular system [6–10]. Strain placed on the cardiovascular system can manifest in a number of ways, including serum biomarkers, negative remodeling, and electrocardiographic changes that may be a harbinger of increased morbidity and mortality.

Concern regarding the effect on the heart from endurance exercise, of the sort encountered in marathon running, is not misguided. In an early study on the cardiac effects of endurance exercise, Benito et al. prodded a group of rats to run at high intensity for 60 min daily over 16 weeks. When compared to a control group, the runners had developed right and left ventricular hypertrophy, fibrosis, and were inducible for ventricular tachycardia at a 42% rate, compared to 6% in the control group [11]. More recently in humans, LaGerche et al. analyzed a cohort of 40 highly trained aerobic athletes. The methodology utilized serum markers, echocardiography, and cardiac MRI. They found the right ventricle more profoundly affected by high-intensity exercise than the left, and although the insult was transient, led to speculation about a dose-dependent arrhythmogenic effect of exercise on the RV [12].

Early repolarization pattern deserves specific mention because it has been associated with an increased risk of ventricular fibrillation and sudden cardiac death [4, 13, 14]. However, in otherwise, healthy athletes without heart disease the strong association between athletic performance and ERP appears benign [4]. Typically, ERP will cooccur with other manifestations of the *athlete's heart*, including isolated voltage criteria for LVH [13]. There are ongoing efforts to more clearly and consistently define a prognostic role for ERP, but it appears based on the most respected, current literature on the subject, to be a benign process in athletes [14].

While the current literature focuses on young, male, competitive ultra-endurance athletes rather than the increasingly common gender- and age-diverse recreational marathon runner, it is the latter that healthcare providers are more likely to encounter in the clinical setting. An unfamiliarity with common ECG manifestations of regular or prolonged aerobic exercise may lead to misdiagnosis, unnecessary treatment, unwarranted specialist referral, and the avoidable consumption of scarce healthcare resources.

While our study was not sufficiently powered to draw conclusions about subsets of individuals in the population of marathon runners and their propensity to manifest cardiac stress/injury on the ECG, our work does serve as a building block to better understand typical electrocardiographic responses to marathon running, and perhaps by extension, endurance activity more generally. In doing so, we identified several normal ECG variations in marathon runners spanning age and gender subgroups. While clinicians can and do provide education to their patients about the potential risks associated with marathon running, they should also be familiar with the normal ECG variants associated with significant aerobic activity.

With respect to our case report, each of the results considered above represent normal electrocardiographic findings in athletes, with the exception of the ischemic ST changes observed in a single participant [15]. In particular, the presence of ECG findings such as incomplete right bundle branch block, QRS complexes meeting voltage criteria for left ventricular hypertrophy and alterations in the usual electrocardiographic pattern for ventricular repolarization have the potential, when taken out of context, to prompt misguided concern on the part of healthcare providers. This case report serves as a reminder for clinicians to consider the individual and the contextual basis of ECG findings.

Conflict of Interest

None declared.

References

1. Running USA Web site: Marathon Report [Internet]. United States of America: Running USA. Available at: http://www.runningusa.org/marathon-report-2014?returnTo=annual reports. (accessed 23 December 2014).
2. Hanssen, H., A. Keithahn, G. Hertel, V. Drexel, H. Stern, T. Schuster, et al. 2011. Magnetic resonance imaging of myocardial injury and ventricular torsion after marathon running. Clin. Sci. 120:143–152.
3. Neilan, T. G., J. L. Januzzi, E. L. Lewandrowski, T. T. Ton-Nu, D. M. Yoerger, D. S. Jassal, et al. 2006. Myocardial injury and ventricular dysfunction related to training levels among nonelite participants in the Boston marathon. Circulation 114:2325–2333.
4. Noseworthy, P. A., R. Weiner, J. Kim, V. Keelara, F. Wang, B. Berkstresser, et al. 2011. Early repolarization pattern in competitive athletes: clinical correlates and the effects of exercise training. Circ. Arrhythm. Electrophysiol. 4:432–440.
5. Wen, C. P., J. P. Wai, M. K. Tsai, Y. C. Yang, T. Y. Cheng, M. C. Lee, et al. 2011. Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study. Lancet 378:1244–1253.
6. Almond, C. S., A. Y. Shin, E. B. Fortescue, R. C. Mannix, D. Wypij, B. A. Binstadt, et al. 2005. Hyponatremia among runners in the Boston marathon. N. Engl. J. Med. 352:1550–1556.
7. Clarkson, P. M. 2007. Exertional rhabdomyolysis and acute renal failure in marathon runners. Sports Med. 37:361–363.

8. Jensen-Ursad, M. 1995. Sudden death and physical activity in athletes and nonathletes. Scand. J. Med. Sci. Sports 5:279–284.
9. Kim, J., R. Malhotra, G. Chiampas, P. d'Hemecourt, C. Troyanos, J. Cianca, et al. 2012. Cardiac arrest during long-distance running races. N. Engl. J. Med. 366:130–140.
10. Mohseni, M., S. Silvers, R. McNeil, N. Diehl, T. Vadeboncoeur, W. Taylor, et al. 2011. Prevalence of hyponatremia, renal dysfunction, and other electrolyte abnormalities among runners before and after completing a marathon or half marathon. Sports Health 3:145–151.
11. Benito, B., G. Gay-Jordi, A. Serrano-Mollar, E. Guasch, Y. Shi, J. C. Tardif, et al. 2011. Cardiac arrhythmogenic remodeling in a rat model of long-term intensive exercise training. Circulation 123:13–22.
12. La Gerche, A., A. T. Burns, D. J. Mooney, W. J. Inder, A. J. Taylor, J. Bogaert, et al. 2012. Exercise-induced right ventricular dysfunction and structural remodelling in endurance athletes. Eur. Heart J. 33:998–1006.
13. Quattrini, F. M., A. Pelliccia, R. Assorgi, F. M. DiPaolo, M. R. Squeo, F. Culasso, et al. 2014. Benign clinical significance of J-wave pattern (early repolarization) in highly trained athletes. Heart Rhythm 11:1974–1982.
14. De Ambroggi, L., A. Sorgente, and G. De Ambroggi. 2013. Early repolarization pattern: innocent finding or marker of risk? J. Electrocardiol. 46:297–301.
15. Drezner, J. A., M. J. Ackerman, J. Anderson, E. Ashley, C. A. Asplund, A. L. Baggish, et al. 2013. Electrocardiographic interpretation in athletes: the 'Seattle criteria'. Br. J. Sports Med. 47:122–124.

