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Thallium-201 Myocardial Imaging at Rest in Male Orienteers and Other Endurance Athletes

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ABSTRACT

During the period 1979 to1992, 16 sudden unexpected cardiac deaths were known to have occurred in young Swedish orienteers. Autopsy indicated myocarditis to be the most frequent finding, most often combined with extensive myocardial fibrosis.The aim of the present investigation was to explore whether young male orienteers show a higher frequency than other young elite endurance athletes (controls) in the occurrence of Thallium-201 myocardial perfusion defects at rest, suggestive of fibrosis evoked by myocarditis. Thallium-201 perfusion abnormalities at rest were more frequently found in the controls than in the orienteers (26% vs.12%, $p=0.03$). Uneven Tl-201 perfusion was associated with left ventricular mass ($r=0.32$, $r=0.24$, $p<0.01$, $p=0.02$) and body weight ($r=0.30$, $r=0.31$, $p<0.01$, $p=0.03$) in orienteers and controls, respectively. Echocardiographic left ventricular wall motion abnormalities were found in 11 athletes (9 orienteers and 2 controls) but only two displayed an abnormal Thallium-201 perfusion scan at rest. Perfusion abnormalities at rest did not occur more frequently in the orienteers but were commonly found in both groups of apparently healthy athletes making it futile to discern abnormals from normals. Thallium-201 perfusion aberrations were not associated with left ventricular wall motion abnormalities obtained by echocardiography.

INTRODUCTION

In Sweden, orienteering is a popular sport, being practised by approximately 2% of the population of varying age and at several levels of competition (17). The goal of the sport is to find the fastest track through terrain between checkpoints using a map and compass. During a 14-year span

(1979-1992), 16 sudden unexpected cardiac deaths (SUCD) are known to have occurred among young Swedish orienteers. Symptoms suggestive of heart disease before death had been reported in only five of the SUCD cases. The mean age of the victims was 25 years (range 18-32 years) and 15 were males. All but two belonged to the high-performing elite orienteers. In sharp contrast to prior SUCD reports in young athletes, in young male Swedish elite orienteers a 10-100 fold increase in SUCD rate could be distinguished over the 14 years period (17). Autopsy revealed myocarditis to be the most frequent finding, which was observed in 75%, and unequivocal in 62% of the cases. One case was ascertained as arrhythmogenic right ventricular cardiomyopathy (ARVC), and three cases had ARVC-like alterations in either ventricle suggestive of a disease similar to ARVC. Fibrosis was a highly conspicuous feature that was observed in 15 of the 16 cases, existing concomitantly with inflammation in the cases showing myocarditis, suggesting a subacute or chronic process. No one had signs of premature atherosclerosis, coronary, or valvular anomalies (9). Taken together, these data strongly suggest that the cause of death was electrical instability with subsequent ventricular arrhythmia. No similar cases were seen within other sports in Sweden.

An increased frequency of subclinical myocardial disease was suspected in male elite Swedish orienteers. Therefore, the purpose of the present survey was to explore whether young elite male Swedish orienteers exhibit a higher frequency in comparison with other young elite male endurance athletes (controls) in the occurrence of Thallium-201(Tl-201) single photon emission tomography (SPECT) myocardial perfusion defects at rest, suggestive of fibrosis evoked by myocarditis.

METHODS

Study population. The study group included 94 male elite orienteers, and 46 age-matched male elite cross-country skiers and middle-distance runners, with the skiers and runners serving as controls. The study group was made up of orienteers and controls being (*a*) elite athletes of the senior and junior national teams of each sport and (*b*) young athletes attending special schools for talented performers. All athletes volunteered for the present investigation. In the youngest athletes the training load was 1-2 hours per day of chiefly running or skiing while in the older athletes the training load was 2-3 hours per day. However, during the six months of investigation all elite orienteering competitions were canceled and the orienteers were recommended to decrease their training intensity and load. We do not know to what extent each athlete followed the recommendation (8). The general characteristics of the study population are given in Table 1.

Table 1. General characteristics of study populations

	Controls (n=46)	Orienteers (n=94)
Age (years)	22 (4.1)	22 (4.8)
Height (cm)	181 (5.4)	182 (6.0)
Body weight (kg)	72 (6.0)	70 (6.3)
No. Of subjects tested in centre 1/centre 2	37/9	58/36

The results are presented as mean values; standard deviations appear in parenthesis.

Tl-201 SPECT. Among the SUCD cases no coronary artery disease was found at autopsy. The subjects included in this survey had no history or clinical signs of coronary artery disease and, consequently, perfusion imaging during exercise was not performed.

At rest 90 MBq Tl-201 was injected in an antecubital vein. SPECT data acquisition was initiated 10 minutes after the injection of T1-201. The tests were performed at two different centers. In center one (Center 1) a Picker SX-300 Digital Dyna Camera (Cleveland) was used and in the other center (Center 2) a General Electric AC400 gamma camera was employed. Both cameras were equipped with a low energy, high resolution parallel hole collimator. The acquisition was performed in 180° body contour rotation from left posterior oblique 45° to right anterior oblique 45°, 32 angels, in 64x64 matrix. The acquisition time was 30 s/angle in Center 1 and 40 s/angle in Center 2. Data were acquired in two symmetrical 20% windows centered at the 75 keV and 167 keV peaks. In Center 1 the data were filtered with a count adaptive Metz filter and reconstruction was done on a PDP 11/73 computer (DEC, Maynard) by means of a commercially available software (SPETS-TSX, Nuclear Diagnostics, Stockholm, Sweden). One pixel (6.3 mm) wide slices were reconstructed. In Center 2 the data were filtered with a Hanning filter (critical frequency 0.82 cycles/cm). After reconstruction, the data were sent to Center 1 for evaluation.

Evaluation and quantification of the reconstructed studies were done by a previously described technique (10). Briefly, the method displays a sagittal reference image and the coronal slice corresponding to a moveable slice selector on the sagittal reference image simultaneously. The heart was divided into three equally sized portions: basal, a middle, and an apical third by adding slices. The myocardium were divided into 30° sectors (i.e. each set of coronal slices for the three portions were divided into 12 sectors). The visual evaluation was carried out by applying a mixed colour/black and white colour table and each of 36 sectors were coded 0-3: 0 = no perfusion defect; 1-3 = mild, moderate and severe perfusion defect, respectively. The code given to each sector was visually analyzed and a consensus was reached between two expert observers. Perfusion defects in two or more attached segments of which at least one sector was scored 2 or

3 was defined as abnormal. Thus, as an estimate of the perfusion uniformity, the total sum of the perfusion scores was calculated for each athlete.

Echocardiography. All subjects included underwent an echocardiographic examination at rest. Left ventricular (LV) M-mode measurements were obtained according to the American Society of Echocardiography criteria (13) and LV wall motion analysis was carried out according to a 16-segment model. The echocardiographic data have been described elsewhere (7,8).

Statistical analyses. Results are expressed as means and standard deviation (SD). Group differences were analyzed using 95% confidence limits of the mean and considered statistically significant when the confidence limits of the mean did not overlap. Chi-2 test was used for comparison of non-parametric data between the groups. Bivariate relations were explored using Pearson's correlation coefficient. A p-value <0.05 was considered statistically significant.

RESULTS

Tl-201 SPECT. The data from the evaluation of the Tl-201 perfusion studies are depicted in Table 2. There was no significant difference between the study groups in the territorial arrangement of perfusion defects. However, perfusion abnormalities were found more frequently in the control group than in the orienteers (26% versus 12%, p=0.03).

In both the orienteers and controls a positive univariate correlation was observed between perfusion score and LV mass (orienteers: r=0.32, p<0.01; controls: r=0.24, p=0.02) and between uneven perfusion and body weight (orienteers: r=0.30, p<0.01; controls: r= 0.31, p=0.03).

Table 2. Summary of Tl-201 SPECT data in orienteers and controls

	Controls (n=46)	Orienteers (n=94)
Number of sectors	1656	3384
Sectors scored 0	1525 (92.1%)	3160 (93.4%)
Sectors scored 1	113 (6.8%)	205 (6.1%)
Sectors scored 2	17 (1.0%)	16 (0.5%)
Sectors scored 3	1 (0.1%)	3 0.1%)
Subjects with abnormal perfusion	12 (26%)	11 (12%)

Abnormal Tl-201 myocardial perfusion was defined as two or more attached sectors of which at least one sector was given a score of 2 or 3.

Electrocardiogram. Of the 140 athletes studied, five (all orienteers) had an abnormal electrocardiogram (T wave inversions in the precordial leads) at rest (8). One of these athletes had an abnormal Tl-201 perfusion scan.

Echocardiography. The echocardiographic examination revealed that nine orienteers and two controls exhibited LV wall motion abnormalities at rest at (8). Of these 11 athletes only two athletes had an abnormal Tl-201 perfusion.

DISCUSSION

Myocarditis as a cause of SUCD in young athletes has been reported to be, on average, about 12% (11). Therefore, the fact that the majority of SUCD cases in Swedish orienteers had histopathological findings suggestive of myocarditis, most often combined with extensive myocardial fibrosis, is unique (9). The fact that clusters of SUCD in athletes are rare and that no similar cases were seen within other sports in Sweden suggests a common denominator to elite orienteers underlying these deaths.

Several cardiac diseases have been recognized to provoke an abnormal Tl-201 myocardial perfusion both at rest and during exercise. In addition to ischemic heart disease, perfusion uptake defects have been reported in hypertrophic cardiomyopathy, myocarditis and recently, in apparently healthy endurance athletes (4,5,12,15,16). Myocardial fibrosis provoked by subacute or healed myocarditis may produce LV myocardial blood flow abnormalities that can be detected using TI-201 SPECT (16). In the present investigation myocardial perfusion abnormalities, suggestive of an increased occurrence of fibrosis provoked by myocarditis, were not found to occur more frequently in the young elite male Swedish orienteers than in the other endurance athletes serving as controls. However, 12% of the orienteers and 26% of the controls had an abnormal Tl-201 perfusion scan at rest. Utilizing Tc-99 MIBI-SPECT Bouvier *et al.* (4) found perfusion defects both at rest and during exercise in the majority of the apparently healthy young athletes they studied. The reason for the uneven perfusion in athletes remains obscure but several explanations have been proposed. Uneven myocardial capillary blood volume, LV hypertrophy and differences in anthropometric data, provoking soft tissue attenuation disparities, have all been implicated in precipitating the observed myocardial perfusion abnormalities (2,4), although there is no experimental evidence to suggest that LV myocardial perfusion is non-uniform in a normal LV (1,14). Thus, variations in LV wall thickness may exhibit perfusion artifacts because of the relation between count density and LV wall thickness (6). Our data demonstrate a positive

that the physiological increase in LV wall thickness due to extensive and prolonged endurance training is one factor accounting for the frequently observed non-uniform perfusion in endurance athletes. In addition, despite the small variation in body weight, perfusion score was associated with body weight in orienteers and controls alike, suggesting that perfusion artifacts may be induced by soft tissue attenuation in endurance athletes.

The echocardiographic examination revealed nine orienteers and two controls with LV wall motion abnormalities (8). The majority of the wall motion abnormalities were mild hypokinesia except in two orienteers that displayed severe LV hypo- and akinesia (8). We found no agreement between the wall motion abnormalities and the Tl-201 perfusion defects. A possible explanation for the absence of correlation between the Tl-201 results and the echocardiographic findings may be found in the observation that the wall thickening observed at echocardiography has its origin primarily from the endocardial one-third of the LV wall and sub-endocardial scars may be too small to be visible by Tl-201 perfusion imaging. On the other hand, scars comprising the epicardial two-thirds of the myocardium may theoretically have a normal echocardiogram but an abnormal Tl-201 perfusion scan. Nevertheless, our data suggest that true perfusion defects may be concealed by the commonly found perfusion abnormalities in athletic hearts, making it fruitless to distinguish between abnormals and normals. The data further suggest that the frequently observed non-uniform perfusion in apparently healthy athletes has a complex etiology and is independent of the perfusion marker utilized (4). Furthermore, scintigraphic perfusion data obtained in sedentary subjects appear to be of limited value when evaluating myocardial perfusion in young male endurance athletes.

Study limitations. Among the SUCD cases, no significant coronary artery disease or abnormality was found at autopsy. Exercise tests were not performed in the study group and controls since the subjects included in this survey had no history or clinical signs of coronary artery disease. Quantitative imaging analysis was not performed. Nonetheless, expert visual analysis has been shown to be comparable to automatic quantitative analysis (3).

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