

# Acute Cardiovascular Complications Due to Physical Exercise in Male Teenagers

Zijad Duraković<sup>1</sup>, Marjeta Mišigoj-Duraković<sup>2</sup>, Ilkka Vuori<sup>3</sup>,  
Naima Čorović<sup>4</sup>, Slobodan Kuvalja<sup>5</sup>, Dubravka Kuvalja<sup>6</sup>, Josip Škavić<sup>7</sup>  
and Marija Definis-Gojanović<sup>8</sup>

<sup>1</sup> Department of Internal Medicine, University Hospital Center »Zagreb«, Zagreb, Croatia

<sup>2</sup> Department of Kinesiological Anthropology, Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia

<sup>3</sup> UKK Institute for Health Promotion Research, Tampere, Finland

<sup>4</sup> Institute for Medical Research and Occupational Health, Zagreb, Croatia

<sup>5</sup> Cybex Center for Isokinetic Diagnostics, Zagreb, Croatia

<sup>6</sup> Pediatric Out-patient Department, Zagreb, Croatia

<sup>7</sup> Institute for Forensic Medicine and Criminology, School of Medicine, University of Zagreb, Zagreb, Croatia

<sup>8</sup> Department of Pathology and Forensic Medicine, University Hospital »Firule«, Split, Croatia

## ABSTRACT

*Five sudden cardiac deaths in male adolescents (age 14–18 years) were detected in a 5-year period in Croatia. Two of them had been engaged in physical exercise at school, one as a professional soccer player, one in recreational swimming, and the fifth had just finished secondary school and was working at the site. All of them were autopsied and in three congenital cardiovascular diseases was found. Two had hypoplastic coronary arteries. The third had hypertrophic cardiomyopathy with interventricular wall of 40 mm. The fourth had normal heart findings including coronaries, but had bilateral pneumonia with a possible altitude (non-cardiogenic) pulmonary edema. The fifth had a chronic myopericarditis with an aneurysm of the left ventricle. All of them had not reported definite symptoms at exertion. According to this data, the death rate in adolescent males in Croatia during or after recreational physical exercise was 1/100,000 per year or 5/500,000 in five years. Thorough preparticipation medical examination including indicated laboratory tests and avoidance of heavy exertion at the time of respiratory infection might have helped to avoid some of the lethal events.*

**Key words:** teenagers, physical exercise, sudden death

## Introduction

Health-related incidents in connection with exercise are very scarce in healthy individuals. In persons under 30 years of age who die during or immediately after physical exercise, the most common reasons are various cardiac diseases: congenital heart disease (hypertrophic cardiomyopathy, congenital coronary artery anomalies, including abnormal origin of coronary artery, hypoplastic coronary artery, myocardial bridging); aortic stenosis; aortic dissection (often associated with the Marfan syndrome); myocarditis (the incidence being higher than expected); idiopathic dilated cardiomyopathy; mitral valve prolapse; idiopathic cardiac hypertrophy; infiltrating cardiomyopathies (amyloidosis etc.), right ventricular dysplasia, a long Q-T interval syndrome, the Brugada syndrome: right bundle branch block, the right precordial ST-segment elevation associated with ventricular tachycardia<sup>1–5</sup>. Risk factors for sudden death associated with exercise include positive familial history for conditions associated with sudden death, cardiovascular diseases and symptoms suggesting them: syncope recurrent, exercise-induced, non-neurogenic in nature, anginal chest pain, palpitations, dyspnea, and seizure activity<sup>6</sup>. Adolescents with these risk factors should be referred to a cardiologist for diagnostic and therapeutic interventions<sup>6–8</sup>. Therefore, it is important that there are opportunities for medical check up prior to the beginning of strenuous exercise training and competition as well as medical control during the season for persons that participate in intensive exercise.

The aim of this study was to analyze causes and characteristics of sudden cardiac deaths that occurred in adolescents during or after physical exercise in a five-year period in Croatia.

## Sample and Methods

The data presented here is part of a large retrospective study in Croatia dealing with 43 sudden and unexpected deaths due to physical exercise in a 30-year period, collected from the whole population of Croatia of all ages and both sexes, consisted 4,500,000 persons. These deceased cases were found from the Public-Health Registry, Sport's clubs and Services of Forensic Medicine. In the years 1998 to 2002 we discovered five sudden and unexpected cardiac deaths due to school, professional or recreational physical exercise in male adolescents 14 to 18 years old. Two of them had been involved in school physical education, one in professional soccer playing, one in recreational swimming for many years, and one had just finished secondary school and was working at the site. All of the victims had not reported any symptoms.

## Results

Pertinent data of the five cases is presented in the Table 1. A forensic autopsy was performed in all subjects. Coronary anomalies were found in two of them: in the 17 years old professional soccer player, hypoplastic right coronary artery, narrowed ascending aorta, acute suppurative inflammation of both tonsils and subacute myocarditis were discovered. In the 14 years old school boy hypoplastic aorta and hypoplastic coronary arteries were found. The third, the 15 years old boy who died while playing basketball in school, had hypertrophic cardiomyopathy (thickness of the interventricular septum 40 mm – normal finding: up to 11 mm), and of the left ventricle 17 mm (normal finding 12 mm). The fourth victim, the 18 years old adolescent, had normal heart finding, bilateral pneumonia and possible high altitude non-cardiogenic pulmonary edema. He was hospitalized in an Intensive Care Unit and dying after 24 hours.

**TABLE 1**  
CHARACTERISTICS OF FIVE MALE ADOLESCENTS – SCHOOL BOYS WHO DIED SUDDENLY  
DUE TO PHYSICAL EXERCISE

Case	Age	Physical exercise	Symptoms	Physical finding/ ECG	Lethal event	Resuscitation	Forensic autopsy
1	17	Professional soccer player	No	No data	February 1998 during a game	Yes	enlarged heart, right coronary artery hypoplastic to 1 mm, ascending aorta narrowed to 10 mm, subacute myocarditis, acute bacterial inflammation of both tonsils, lungs and cerebral edema
2	14	Physical exercise in a school	No	No data	October 2001 during physical exercise	Yes	hypoplastic aorta, hypoplastic coronaries, pulmonary edema
3	15	Basketball player	No	No data	May 2000 during a game	Yes	left ventricular wall 17 mm, interventricular septum 40 mm, normal coronaries, myocardial fibrosis and scars up to 3 mm in diameters, pulmonary and cerebral edema
4	18	just finished secondary school – working at the site	No	No data	December 2001 »caught a cold« and felt exhausted, died suddenly during work	Yes	normal heart finding, normal coronaries, bilateral pneumonia, possible high altitude non-cardiogenic pulmonary edema, cerebral edema
5	18	Swimming recreationally	No	No data	June 2002 during swimming	Yes	Chronic myopericarditis with left ventricular fibrosis and myocardial scars, aneurysm of the left ventricle 2 cm in diameter, normal coronaries, pulmonary edema

The fifth boy, who died during recreational swimming, had signs of chronic myopericarditis with an aneurysm of the left ventricle. The mechanism for the lethal event in all five cases was probably malignant ventricular arrhythmia.

On the basis of our findings, the rate of sudden and unexpected death in boys during or after recreational physical exercise in secondary schools in Croatia was 1/100,000 per year or 5/500,000 in five years (1998–2002).

## Discussion

Many possibilities exist in defining an exertion-related sudden cardiac death<sup>6</sup>. The time period needed for the cardiovascular system to return to resting steady state varies with many factors such as the type, intensity and duration of the activity, and the health status and physical condition of the individual. Thus, it is not easy to define exactly what are an exertion-related death and especially a sudden death caused by exercise. Some researchers count only deaths during or immediately after the cessation of exercise as exercise-related deaths, while some authors include also deaths that had occurred 30 minutes, 60 minutes or even more after the exercise<sup>9,10</sup>.

According to our data the rate of sudden and unexpected death during or after recreational physical exercise was 1/100,000 per year or 5/500,000 in five years (1998–2002) in boys (and none in girls) in or immediately after secondary schools in Croatia. This is lower incidence than in other age groups in Croatia. For example the rate of sudden and unexpected death during or after physical exercise in male physicians-specialists was much higher than in adolescents: 33.6/100,000, and also higher than in men aged 30–70: 1.7/100,000 per year in Croatia, and in the elderly: 1.3/100,000 per year<sup>11,12</sup>.

Although the incidence of sudden unexpected death in the school boys was low, our findings bring up once again the question, whether some or all of these incidents could have been prevented. None of the boys had reported any noticeable symptoms at exertion. However, all of them suffered from chronic or acute cardiac or other diseases: two (cases 1 and 2) had congenital hypoplasia of the coronary arteries, one together narrowing of the ascending aorta and subacute myocarditis, one (case 3) had hypertrophic cardiomyopathy, one (case 5) had a chronic myopericarditis with an left ventricular aneurysm. In one case (case 4) the heart findings were normal but there was bilateral pneumonia and possible non-cardiogenic pulmonary and cerebral edema. This 18 years old adolescent was badly nourished, skinny, exhausted because of a »flu«, and possibly dehydrated. The possible cause of death might have been hyponatremic encephalopathy with consecutive noncardiogenic pulmonary edema during bilateral pneumonia. Noncardiogenic pulmonary edema could be a clinical manifestation of hyponatremic encephalopathy<sup>13</sup>.

The frequency of all cardiovascular malformations, by soma data, is 0.8% at birth in autopsy series of near 5,000 cases<sup>14</sup>. The relative frequencies of cardiac malformations at birth (percent of all newborn) have been reported as follows: narrowed ascending aorta 6.1%, pulmonary valvular stenosis 6.9%, an atrial septal defect 9.8% in this population. The frequency of subacute myocarditis is 1% in systemic infections<sup>14</sup>. Thus, the prevalence of congenital heart diseases, especially in serious forms, in the population is low. This causes problems in finding valid and economical systems and methods for their diagnosis.

The most common abnormalities of young persons who have died suddenly during or after physical exercise have been found to be hypertrophic cardiomyopathy

(especially in young competitive athletes, 36%) or congenital coronary anomalies<sup>15–17</sup>. In Italy (Veneto region) in a 17-year period (1979–1996) among 49 competitive young athletes (44 male and 5 female) who died suddenly, hypertrophic cardiomyopathy was observed in only one subject or 2% in autopsy<sup>18</sup>, and coronary anomalies in 18% of the victims. In a Swedish study<sup>2</sup>, in a period of 14 years, 16 sudden and unexpected cardiac deaths among young orienteers aged 18–27 years (15 male and one female) were found. Six had acute myocarditis, four arrhythmogenic right ventricular dysplasia, and two had healed myocarditis. This data demonstrates that the causes of sudden death of young athletes at exertion can vary greatly in different countries and athletic populations. The most common mechanism for lethal event is ventricular fibrillation. The most difficult problem is that cardiac disease in young persons is usually not recognized prior to death, as was the case also in our study.

A recent American study<sup>10</sup> suggests that a person can begin a gradual exercise program without consulting a physician, if the answer is no to the following questions: 1) history of heart trouble; 2) heart murmur, 3) heart attack, 4) arterial hypertension; 5) diabetes mellitus, 6) arthritis; 7) family history of premature coronary heart disease; 8) exercise-related shortness of breath, faintness, dizziness, or pain or pressure in the chest, neck, shoulder or arm. In order to give reliable answers to these questions, information from prior medical examinations is often needed<sup>9,19</sup>. Carefully collected anamnestic data with special attention to personal and familial (parental sudden death) cardiovascular history, personal physical examination, an electrocardiogram at rest (12-leads), and especially an echocardiographic study on the basis of other information are essential in every potential athlete or in suspicious cases. Echocardiography is today a standard

non-invasive cardiac investigation especially in screening of congenital heart diseases. A 12-lead electrocardiogram is the most valuable preparticipation cardiovascular modality of these three mentioned methods at the beginning, and an echocardiography is a superior method for detecting congenital cardiovascular anomalies<sup>16,19</sup>. However, it cannot be considered as a large-scale screening examination of symptomless individuals because of the equipment and expertness needed and also because of diagnostic uncertainties. Echocardiography can give a false positive finding e.g. in borderline thickness of the left ventricle or in dilated heart cavities. A false negative finding can occur in cases of hypertrophic cardiomyopathy which might not be detectable until the adolescent period<sup>15</sup>.

Detection of premonitory cardiac symptoms, such as shortness of breath, history of exertion syncope or chest pain, has to lead to diagnostic procedures such as ergometry, thallium stress test, echocardiography and coronarography especially in competitive athletes, according to validated schemes<sup>17</sup>. Physical exercise is contraindicated in a case of acute infection, especially a respiratory one. In this report the cause of death was an acute respiratory infection, in one previously healthy adolescent. In another boy with hypoplastic aorta and coronaries and subacute myocarditis, a respiratory infection probably was a trigger.

Thus, examination of the anamnestic and autopsy findings in the six cases of this material suggests that avoidance of heavy exertion at the time of respiratory infection (cases 1 and 4) and thorough preparticipation physical examination and indicated diagnostic tests (cases 3 and possibly 5) could have helped in avoiding the fatal event.

In conclusion, this study covering all sudden deaths related to exercise in the adolescent population of Croatia during a 5-year period shows that the incidence of

these deaths is smaller than in other males engaged in physical exercise. However, in part of the cases avoidance of heavy exertion at the time of respiratory infection or thorough clinical examina-

tion and indicated laboratory tests prior to involvement in intensive athletic training might have helped to avoid the lethal event especially in teenagers.

## REFERENCES

1. CORRADO, D., C. BASSO, M. SCHIAVON, G. THIENE, N. Engl. J. Med., 339 (1998) 364. — 2. WESSLEN, L., C. PAHLSON, O. LINDQUIST, E. HJELM, J. GNARPE, E. LARSSON, U. BAANDRUP, L. ERIKSSON, J. FOHLMAN, L. ENGSTRAND, T. LINGLOF, Eur. Heart J., 17 (1996) 902. — 3. GUS-SAK, I., C. ANTZLEVICH, P. BJORREGARD, J. A. TOWBIN, R. CHAITMAN, J. Am. Coll. Cardiol., 33 (1998) 5. — 4. DURAKOVIĆ, Z., M. MIŠIGOJ-DURAKOVIĆ, R. MEDVED, J. ŠKAVIĆ, Kinesiology, 31 (1999) 68. — 5. ROGUIN, N., A. WISHINIAK, Cardiol. Young., 10 (2000) 669. — 6. WALSH, C. A., Adoles. Med., 12 (2001) 105. — 7. KESTELOOT, H. E., J. Cardiol., 37 (2001) 1. — 8. PFISTER, G. C., J. C. PUFFER, B. J. MARON, J. Am. Med. Assoc., 283 (2000) 1597. — 9. VUORI, I. Acta Med. Scand., 711 Suppl. (1986) 205. — 10. PEARSON, T. A., S. N. BLAIR, S. R. DANIELS, R. H. ECKEL, J. M. FAIR, S. P. FORTMANN, B. A. FRANKLIN, L. B. GOLDSTEIN, P. GREENLAND, S. M. GRUNDY, Y. HONG, N. HOUSTON MILLER, R. M. LAUER, I. S. OCKENE, R. L. SACCO, J. F. SALLS, S. C. SMITH, N. J. STONE, K. A. TAUBERT, Circulation, 106 (2002) 388. — 11. DURAKOVIĆ, Z., M. MIŠIGOJ-DURAKOVIĆ, J. ŠKAVIĆ, N. ČOROVIĆ, Coll. Antropol., 26 (2002) 239. — 12. DURAKOVIĆ, Z., M. MIŠIGOJ-DURAKOVIĆ, J. ŠKAVIĆ, Coll. Antropol., 26 (2002) 509. — 13. AYUS, J. C., J. VARON, A. I. ARIEFF, Ann. Intern. Med., 132 (2000) 711. — 14. GERLIS, L. M., Cardiovasc. Pathol., 5 (1996) 11. — 15. MARON, B. J., J. SHIRANI, L. C. POLIAC, R. MATHENGE, J. Am. Med. Assoc., 276 (1996) 199. — 16. GOBLE, M. M., Indian. J. Pediatr., 66 (1999) 1. — 17. BASSO, C., B. J. MARON, D. CORRADO, G. THIENE, J. Am. Coll. Cardiol., 35 (2000) 1493. — 18. CORRADO, B. C., G. THIENNE, Cardiol. Rev., 7 (1999) 127.

Z. Duraković

Department of Internal Medicine, University Hospital Center »Zagreb«, Kišpatićeva 12,  
10000 Zagreb, Croatia

e-mail: zdurakovic@mef.hr

## AKUTNE KARDIOVASKULARNE KOMPLIKACIJE TIJEKOM ILI NEPOSREDNO NAKON TJELOVJEŽBE U ADOLESCENATA

### SAŽETAK

U petogodišnjem razdoblju (1998–2002) u Hrvatskoj je zabilježeno 5 naglih i neočekivanih smrti tijekom ili nakon tjelovježbe među adolescentima dobi 14–18 godina. Svi su obducirani i u četvorice je nađena prirođena bolest srca. Dva su imali hipoplastične koronarne arterije, jedan od njih uz to i bakterijsku upalu tonzila, suženu aortu i subakutni miokarditis. Treći je imao hipertrofijsku kardiomiopatiju. Četvrti je bolovao je od obostrane upale pluća s vjerojatnim nekardiogenim edemom pluća. Peti je imao prirođenu aneurizmu lijeve klijetke. Nitko od njih nije navodio subjektivne smetnje za vrijeme napora. Prema tim podacima, stopa smrti za vrijeme ili neposredno nakon tjelovježbe u adolescenata u Hrvatskoj iznosi 1/100,000 godišnje ili 5/500 000 u 5 godina. Imperativ je prije uključivanja u napore tjelesnog vježbanja, provesti klinički pregled kao i laboratorijske parametre s naglaskom na 12-kanalnom elektrokardiogramu, pokusu opterećenjem i na ehokardiogramu.