

# Cardiac risk in swimmers

ANTONIO SPATARO, DI PAOLO FM, SI SALVO V, RUGGERI AE, PARISI A, ALABISO A, VOLTA B and PIGOZZI F.

*Institute of Sports Medicine  
I.S.E.F., Rome, Italy*

## ABSTRACT

SPATARO A., Di PAOLO F.M., Di SALVO V., RUGGERI A.E., PARISI A., ALABISO A., VOLTA B. and PIGOZZI F. Cardiac risk in swimmers. *Kinesiology*, Vol. 2, No. 1, pp. 75-80, 1997. Swimming exercise determines various cardiovascular reflexes and induces complex haemodynamic changes: the increased cardiac output, the occurring tachycardia and the higher mean arterial blood pressure, all result in an augmentation of the cardiac work. Thus, long-term athletic training primarily causes changes of the left ventricular morphology represented by large diastolic cavity dimension and high values of wall thickness. These adjustments and morphological changes of the heart, however, may assume a relevant role in the dramatic revelation of latent cardiovascular pathologies. In young athletes a sudden death is more often due to congenital cardiovascular diseases while in older athletes it is usually caused by coronary artery disease. There is a wide interest in the assessment of clinical and instrumental protocols intended to the precocious identification of all cardiopathies at risk for determining sudden death during sport activity. The present study considered the different role of clinical examination, resting ECG and stress ECG (step test) in the identification and evaluation of cardiological abnormalities. The study group consisted of 158 athletes (age  $14.2 \pm 7.0$ ; 40 female, 118 male), 104 swimmers, 2 syncro, 52 waterpolo; all athletes were apparently healthy and in low or medium training condition. The results show that: a) Family history: 11 athletes referred familiarity for coronary liean disease, 13 for hypertension, 14 for diabetes. b) Personal history and physical examination: all athletes were asymptomatic and had no pathological findings at the clinical evaluation, c) ECG at rest: 5 athletes had a BAV I (the A-V conduction normalized after Harvard-Montoye Step test), 1 had a complete right bundle branch block, 1 had negative T wave in the precordial leads (V4-V6), 1 had runs of supraventricular tachycardia (also documented by means of a 24-hours dynamic ECG monitoring), 6 had isolated supraventricular beats, 2 had isolated and occasional ventricular beats, and d) Submaximal stress ECG: all athletes had normal findings; 20 Echo doppler in 13 AT, bicycle ergometries in 4 AT and 24-hours ambulatory ECG monitoring in 3 AT were performed and their results were in the range of normality. The clinical and instrumental examination provided by our diagnostic protocol did not reveal cardiopathies at risk of causing sudden death such as hypertrophic cardiomyopathy or congenital heart malformation. All athletes were eligible tor competitions. Our results confirm the importance of pre-participating screening for the evaluation of cardiac risk in swimmers. For identification of various cardiopathies at risk for sudden death non invasive 24 hour ambulatory ECG monitoring and 2 D echo doppler are recommended in athletes with suspected clinical and ECG findings for cardiopathies.

**Key words:** CARDIAC RISKS, SUDDEN DEATH

Cardiac output, heart rate, stroke volume and systolic blood pressure is substantially increased during the exercise of swimming. Thus, this type of exercise primarily causes an increase in end-diastolic volume and a decrease in end-systolic volume (increase contractile state). Athletes who participate in this kind of activity (with a high dynamic and moderate static component) have a larger absolute left ventricular mass and chamber size in comparison to sedentary subjects. Those changes in the left ventricular morphology actually represent an adaptation to an increased ventricular load and are generally described as the "athlete's heart". Numerous echocardiographic studies have investigated the effects of athletic training on cardiac dimensions. Swimmers were found to have the largest left ventricular diastolic cavity wall thickness and mass. These physiological adaptations may obviously raise diagnostic doubts: the physician might erroneously consent sporting activities to athletes with a risk of cardiopathy whilst on the other hand, may exclude from sports subjects who would really not be exposed to any risk in spite of the positive clinical and instrumental findings. Fortunately, events concerning sudden death of athletes are rare occurrences. Nevertheless, the death of an athlete, during competition or training, creates great alarm in other athletes, parents and general public.

## **Epidemiology**

Most reviews of athletes dying suddenly are retrospective studies of selected cases and are not population based. Therefore, the incidence of the various causes of sudden death during competition or training in athletes is unknown. The aetiology of sudden death in athletes varies with respect to age. In athletes over the age of 35 years, acquired coronary artery disease is by far the most common underlying cardiac abnormality; in younger (less than 35 years old), exercise associated deaths are related with cardiac anomalies, for example hypertrophic cardiomyopathy arrhythmogenic right ventricular dysplasia, congenital heart malformations and abnormalities of the great arteries, wpw syndrom, myocardites, mitral valve prolapse and Marfan's syndrome. Furthermore, the incidence of sudden death in relation to the type of sport has received little or no systematic study. Paradoxically, the most fatal incidents occur in sports which are generally considered as safe or very healthy. Data on sudden death in sport reflect predominantly two factors: The distribution of various types of sport within a given population and the average age of its participants. In a study on sudden death related to sport in Japan (Murajana et al 1994), running was most frequent at the age of <40 years, golf at the age of 40-59 years. In swimmers sudden death occurred in 58 subjects at the age of 0-39 years, in 14 subjects at the age 40-59 years and in 8 subjects at the 60 years or more, for a total of 80 (12,4%). Of 332 sudden deaths at the age of less than 40 years swimming was observed in 58 (17,5%); of 166 at the age of 40 to 59 swimming was observed in 14 (8,4%). The most frequent cause of sudden death is coronary artery disease. In 81 fatal events which happened in Rhode Island within 4 years 9 occurred during swimming (Ragosta et al 1984). Golf and football produces in the USA a high number of cardiac events whilst in Italy and Germany soccer is the main factor (Spataro 1985).

### **Efficiency of screening**

The study of Maron (Maron et al 1986), carried out on 29 top level athletes (ranging from 13 to 30 years of age) dying suddenly, showed that: 7 athletes had been clinically suspected of cardiovascular pathology and out of these 2 cases were characterized with autoptic evidence of hypertrophic cardiomyopathy. It must be emphasized that in 5 cases with autoptic evidence of hypertrophic cardiomyopathy the pathology could at least be suspected on the findings of the resting ECG.

Thompson (Thompson et al 1979) found that on 13 subjects the acute event occurred during or after a jogging session and was caused by coronary atherosclerotic disease. 5 of the 13 subjects had suffered from cardiovascular disease (hypertension, atrial fibrillation, supraventricular tachycardia and myocardial infarction). 9 subjects had undergone a resting ECG in the preceding two years and 3 of them had showed electrocardiographic abnormalities (atrial fibrillation, left ventricular hypertrophy and past myocardial infarction), but only one had been suggested by the physician to interrupt his sporting activity. 6 subjects suffered from prodromic symptoms, but only 2 consulted a physician, while one missed the appointment he had asked for, because of a "stomach ache", but regularly attended his daily training session. In the 10 subjects that died of myocarditis 2 cases had vertigo and syncopal attacks while 7 had an infective pathology that could have caused the myocarditis. The authors concluded that it is advisable to interrupt physical training and participation in competitions during rhinopharyngitis, influenza or post-influenza enteritis because these pathologies could contribute to the onset of a myocarditis.

Right ventricular cardiomyopathy was identified as a probable cause of death in 12 subjects in study conducted post mortem on 60 individuals under 35 years of age who had died suddenly. In 7 subjects palpitations often accompanied by syncopal episodes had occurred previously; basal electrocardiographic findings (t wave inversion in precordial leads) were available for five subjects. Investigations carried out by Furlanello and co-workers (1984) on sudden deaths, in relation to 766 athletes who were found to be eligible on the basis of severe protocols, found that eight of these were struck by sudden death. All these athletes had arrhythmias and palpitations before death. Cardiac disease potentially responsible for sudden deaths can be partially identified and not totally by pre-participation screening of athletes.

Fatal non-traumatological events cannot be considered as incidental. All unclear signs and symptoms of cardiovascular conditions in athletes should be very carefully investigated. The large discrepancies in the results of these studies can be explained by differences in the study populations and age groups as well as the methods of investigation which are applied (Table 1). The few studies carried out on top level athletes show that during the years the incidence of latent cardiopathies has changed. Venerando and Dal Monte (1965) examined with clinical checks 26700 young athletes between 14 and 16 years of age, and found out that there were cardiological alterations in 7% of the subjects. These alterations were characterized by valvulopathies and arterial hypertension. A following study carried out on 12000 athletes

with clinical ECG at rest and after step test checks, revealed congenital cardiopathies and ECG alterations at risk in 0,03% of the subjects.

**Table 1.** Studies on sudden death during physical activities in young individuals.

	<b>Waller 1985</b>	<b>Maron et al 1986</b>	<b>Furlanello et al 1984</b>	<b>Van Camp et. al 1995</b>
subjects	87	29	766	160
sudden death	87	29	8	160
age	11-30	<36	21.1	13-24
right ventricular cardiomyopathy			25%	0.6%
myocarditis	1%		12.5%	4.4%
coronary artery anomalies	35%	14%		10%
coronary heart disease	6%	12%	37.5%	1.8%
hypertrophy cardiomyopathy	22%	66%		31.8%
mitral valve prolapse	5%			0.6%
aortic rupture	3%	7%		1.2%
undetermined	25%	27%		4.3%

In our study on 1505 Olympic athletes evaluated with ECG at rest and after a stress test and routinely with an echo-cardiography, 3,4% of athletes were found to be affected with cardiological alterations, in particular: mitral valve prolapse in 3,2%, bicuspid aorta in 0,07% and arrhythmias in 2,8%.

Another important contribution is given to us by the Manitoba study conducted on 3983 men with an average of 30,8 years of age at the time of the beginning of the investigation (1948) which continued for another 30 years with medical and ECG checks. During this period 70 cases of sudden deaths occurred which had no previous medical record of cardiopathy. 4% of the cases had less than 40 yrs of age while 35% were over 60 yrs of age. 25 postmortems were carried out; although no clinical symptomatology was observed, all the cases were characterized by coronary arteriosclerosis. Previous ECGs were examined; 71,4% of the cases presented electrocardiographic alterations. Such alterations, in a decreasing fashion were: anomalies of the S-T tract and the T wave, premature ventricular beats, left ventricular hypertrophy, left branch block, left axis deviation. All these findings were actually in a position to predict significantly the possibility of sudden death. The association of some of these findings resulted in increasing the risk of death.

### **Present study**

The present study considered the different role of clinical examination, resting ECG and stress ECG, in the identification and evaluation of

cardiological abnormalities. We selected 158 athletes (40 female, 118 male), average age  $14,2 \pm 7,0$ ; 104 swimmers, 2 syncro, 52 waterpolo. The assessment was carried out at the Institute of Sport Medicine of the Italian Medical Sport Federation of Rome. In all athletes the first examinations were considered. The diagnostic protocol included: family and personal medical history, physical examination and measurement of the arterial pressure, 12 leads resting ECG, and 12 leads stress ECG (Harvard-Montoye step test). When cardiac abnormalities were suspected, echocardiogram bi-dimensional and doppler, monitored bicycle ergometric test and 24 hours ECG monitoring (Holter) were performed. Blood pressure was consistently or predominantly less than 140/90 mmHg (PAS mean  $111.9 \pm 11.8$  mmHg; PAD mean  $70.9 \pm 7.8$ ). Body surface area averaged  $1.49 \pm 0.38$  m<sup>2</sup>. All athletes were in low or medium training conditions (three or four times per week for 2-3 hours).

Analysis of data revealed the following with respect to family history: 11 athletes referred coronary artery disease within the family, 13 hypertension and 14 diabetes. Personal history and physical examination: all athletes were asymptomatic and had no pathological findings at the clinical evaluation. ECG at rest: 5 athletes had a BAV I (the A-V conduction normalized after Harvard-Montoye Step test), 1 had a complete right bundle branch block, 1 had negative T wave in the precordial leads (V4-V6), 1 had runs of supraventricular tachycardia (also documented by means of a 24-hours dynamic ECG monitoring), 6 had isolated supraventricular beats, 2 had isolated and occasional ventricular beats. Stress ECG: all athletes had normal findings; 13 echocardiographical evaluations, 4 bicycle ergometries, 3 24-hours dynamic ECG monitorings, were performed and their results were in the range of normality.

## **Conclusions**

Competitive sports can put an athlete with a cardiovascular abnormality at medical risk due to an increase in work load on the heart or stress on the vascular system caused by increases in blood flow and pressure and an increase in body temperature. Nevertheless, it should be emphasized that the demands of many competitive sports, for example triathlon, place the athlete on occasional extreme and unusual environmental conditions that may be associated with alterations in blood volume, hydration and electrolytes that, in turn, are reflected in an increased risk of sudden death and progression of disease in the presence of certain cardiovascular abnormalities. There is a wide interest in the assessment of clinical and instrumental protocols intended at the prior identification of all cardiopathies with a risk for determining sudden death during sporting activities.

In Italy, the existence of a unique situation offers a measure of protection at the participation of competitive events. The Italian government has promulgated a legislation dictating the rules for participating in official competitive sporting events, the design of which dictates that every person engaged in competitive sports "must undergo to a preventive and, in a periodical way, to the control of the physical fitness and must achieve a certification of eligibility for the sport in which to participate". According to

the law, the protocol of this screening should include a general physicians' examination and 12 leads scalar ECG with submaximal exercise test, but within the full opportunity (and responsibility) of the examining physician to require more examinations, in case of "reasonable clinical suspicions". Certification of eligibility is eventually issued by the physician and it represents the necessary condition in order to participate in an official athletic event. In Italy the physician is responsible for the accuracy of this assessment and with regards to the final judgment of eligibility. The physician will be prosecuted in a judicial trial with criminal allegations in case of misdiagnosis or incorrect medical evaluation. The program of medical screening, as dictated by the law applies to approximately 6-8 million people (that is the Italian population roughly involved in competitive sports). Although the law has been in force for the last 15 years, this program has not been entirely fulfilled, and it has been estimated that individuals regularly undergoing medical screening are less than 50% of all the potential candidates. This preventive medical program can be judged incomplete. However, evidence suggests that a certain degree of screening and prevention of cardiac accidents has been carried out in consideration of the sizeable number of subjects removed from competition because of cardiac abnormalities detected during screening.

In a survey, referring to data from different sporting medical centres distributed countrywide, reported a mean value of 1197/59153 (2%) from the population of athletes disqualified from competitions and training. 72% of disqualifications originated from cardiac reasons, with arrhythmias, valvular diseases and hypertension being the most frequent. In this study our diagnostic protocol did not reveal cardiopathies at risk of causing sudden death such as hypertrophic cardiomyopathy or congenital coronary anomaly or arrhythmogenic right ventricular dysplasia. This result may be explained by the low occurrence of these pathologies in the athletic population. All our athletes were eligible for competitions. These results confirm the importance of pre-participating screening for the evaluation of cardiac risk in swimmers. Nevertheless, the athletes with positive personal and/or family history, abnormal auscultatory findings and ECG alterations should be studied with echo-cardiography, and 24-hours ECG monitoring ambulatory.

In conclusion, the athletes health care could be improved by: accuracy in the execution of pre-participating visits, performing instrumental examinations whenever their need is suspected on the basis of history, physical examination and ECG findings; information to all level athletes on the risks they take by understating the importance of evaluating their basic health conditions; sanitary education of managers, coaches and all the people involved in the organization and practice of sport activities. In 490 BC the Athenian senate ordered an inquiry for the death of Fidiippides, a young soldier who died while running the marathon. After 2400 years we still do not succeed in facing sudden death with rational intervention programs.

## REFERENCES

- ALLEN H, STANLEY MD, GOLDBERG J, SAHN D, SCHYN and WOJICK R. A quantitative echocardiographic study of champion childhood Swimmers. *Circulation* 55:142-5, 1976.
- BOUHOUR BJ and BOGART C. Sudden death and myocarditis during activities and sport performance. *Int J Sports Card* 2,81,1985.
- BURKE PA, FARBA, UIRMANI R, GOODIN J and SMIALEK SE. Sports-related and non sports related sudden cardiac death in young adults. *AM Heart J* 2:568, 1991.
- FURLANELLO F, BETTINI R, COZZI F, DEL FAVERO A, DISERTORI M, VERGARA G, DURANTE GB, GUARNEIRO M, IBNAMA G and THIENE G. Ventricular arrhythmias and sudden death in athletes. *Ann NY Acad Sci* 427:253-79,1984.
- MARON BJ, EPSTEIN SE and ROBERTS WC. Causes of sudden death in competitive athletes *J AM Col Cardiol* 7:204, 1986.
- MURAJAMA M, OHTA T, TUKODOME S, KAWAKUBOK, KOBOR Y, TOYOSHIMA H and MUSHA H. Recent trend on sudden death related to sport in Japan. *Int J Sports Cardiol* 3:19, 1994.
- PELLICIA A, MARON BJ, SPATARO A, PROSCHAM MA and SPIRITO P. The upper limit of physiologic cardiac hypertrophy in highly trained elite athletes. *N Eng J Med* 324:295-301, 1991.
- PIOVANO G, CASELLI G and VENERANDO A. Cardiopathies observed in athletes. In: Lubich T., Venerando A.,(Eds). *Sports Cardiology Aulo Gaggi*, 1980.
- RAGOSTA M, CRABTREE J, STURNER W and THOMPSON P. Death during recreational exercise in the state of Rhode island. *Med Sci Sports* 16:339, 1984.
- SISCOVICK DS, WEISS NS, FLETCHER RH and LASKY T. The incidence of primary cardiac during vigorous exercise. *N Eng J Med* 311:874, 1984.
- SPATARO A, PELLICIA A, CASELLI G, BIFFI A and ALABISO A. Capobianco L., Piovano G., Arcangelo E.: *Utility of routinary echo-cardiography in the screening of a large population of top level athletes*. Proceed. 2nd International Conference on Sports Cardiology. Bologna Aulo Gaggi, 1989.
- SPATARO A, PELLICIA A, CASELLI G, AMICI E and VENERANDO A. Echo-cardiographic standards in top-class athletes. *Int J Sports Cardiol* 2:17-27, 1985.
- THIENE G, NAVA A, CORRADO D, ROSSI L and PENNELI N. Right ventricular cardiomyopathy and sudden death in young people. *N Engl J Med* 318, 129-33, 1988.
- THOMPSON PD, STERN MP, WILLIAMS P, DUNCANK, HASHELL WI and WOOD P. Death during jogging or running. *JAMA* 242:1265-1267, 1979.
- VAN CAMP SP, BLOOR CM, MUELLER F, CANTU RC and OLSON HG. Non traumatic sports death in high school. *J Sci Sports Exerc* 27:641-647, 1995.
- VENERANDO A and DAL MONTE A. Frequenza delle cardiopatie ignorate nella popolazione giovane sportiva *Annali Sanito Pubblica* 26, 1935, 1965.
- WALLER BH. Exercise-related sudden death in young (age<30 years) and older (age>30 years) conditioned subjects. In: N.K. Wenger (Ed.), *Exercise and the Heart*, 2<sup>nd</sup> ed, Philadelphia: F.A. Davis, 1985.