

Sudden Cardiac Death in Athletes: Tips for Prevention

Hakan Yaman¹, İsmet Akçay², Günay Günay³

¹Retired, Formerly: Department of Family Medicine, Akdeniz University School of Medicine, Antalya, Turkey

²Clinic of Orthopedics, Private Atasam Hospital, Samsun, Turkey

³Clinic of Cardiology, Memorial Hospital, Antalya, Turkey

Cite this article as: Yaman H, Akçay İ, Günay G. Sudden Cardiac Death in Athletes: Tips for Prevention. *Cyprus J Med Sci* 2017; 2: 67-71.

In Turkey, an increase in the number of people interested in running and particularly, in those participating in marathons is quite striking. The age of participants is increasing as well. Nowadays master athletes are often seen in these competitions. Although the benefits of sports are not open to debate, sports events, such as marathons, pose potential risks to participants. Pre-participation evaluations are important as well as follow-ups by a coach for individuals participating in sports to minimize the damage that this paradox can create. Sudden cardiac death (SCD) is the most feared and dramatic situation during organized sports events. Although it is not very common, describing the inflicted trauma is not quite possible. In this review, medical evaluations on adult and elderly athletes, in particular, will be discussed. Coronary artery disease, particularly in this risk group, is the leading cause of SCD. We would like to suggest a three-step evaluation of athletes in this age group. This approach seems to be relatively easy to implement considering its cost effectiveness, and it also helps identifying as many at-risk athletes as possible. Furthermore, we want to emphasize that the regulation of the emergency field of the race environment is very effective in reducing mortality.

Keywords: Sudden cardiac death, cardiac arrest, sports, athletes, acute coronary syndrome, running

INTRODUCTION

In recent years, there has been an increase in the number of individuals participating in a marathon. Whether young or old, they all want to participate in a marathon to prove themselves (1). Along with the aging population, a significant number of individuals are playing sports in their free time. For example, in the United States, 20 million individuals participate in the run every year. More than half of the participants are male and older than 35 years. Among the factors that motivate participation, which has been on the rise for the last 15 years, are the positive health effects of these activities (2). In addition to the psychological effects that the run will provide, there are also positive physical health effects. However, potential harmful effects of a full marathon are also likely to outweigh the benefits. Athletes who take this job seriously also need to prepare themselves for this activity (1). However, it is possible for us to mention a paradox related to sports. Some individuals have sudden cardiac death (SCD) caused by certain underlying structural heart problems, which is often linked to their immobility. In particular, middle-aged and elderly individuals are more susceptible to SCD. SCD due to sports needs further investigation, and it comprises 5%-6% of all SCDs (2).

The prevalence of SCD in sportsmen is 1 in 50,000/year (3). Most of the cases are observed in males (3, 4). Discussed in more detail, the frequency varies from 1 in 200,000-1 in 7,500. This accounts for occasional runners (1/750-18,000) and for marathon runners (1/50-200,000). Majority of the events occur during the half-marathon or marathon, and they mainly take place toward the end of the run (5).

If we evaluate the frequency of the occurrence of SCD in marathon runners according to the duration of the exposure, it would be possible to say that the frequency is very low. The number of deaths in marathons is 1 in 215,000 h, while in non-competitive live sport events, this number is 1 in 396,000 h; in Nordic skiing, it is 1 in 607,000 h (6).

If we were to compare these values with those in healthy individuals, it is possible to see that the risk of SCD is 56 times higher in inactive individuals. For individuals participating in sports on regular basis, this risk is five times higher. On the other hand, mild to moderate participation in sports reduces the risk of SCD by 7-10 times and the risk of myocardial infarction (MI) by 50 times. Even daily runs in moderate levels (5-10 min, <6 mil/min) have significant benefits against mortality (2).

Middle-aged and elderly athletes (age>35 years) will be reviewed in this study. Athletes above 35 years are also called master athletes.

Sudden cardiac arrest and SCD are the sudden halt of cardiac activity and hemodynamic collapse occurring with ventricular tachycardia/fibrillation. Although hypertrophic cardiomyopathy (HCM) is more common in young people, it occurs in the elderly because of structural heart diseases, such as coronary heart disease (CAD), that have developed previously. Whether the outcome is fatal or nonfatal (after a successful cardiopulmonary resuscitation), the state of developing complaints within an hour and the absence of trauma is called SCD (7-9).

In a cumulative of 30-year study, only 4 out of 215,000 marathon runners were diagnosed with SCD. None of them complained during training or before the marathon. Three of them had no complaints before collapsing to the ground. Two of them had completed three marathons before and the other two had participated in their first marathon. Also three of the patients were diagnosed with CAD, but none had structural heart disease (10).

Structural heart diseases are at the forefront, if we closely examine SCD in sports. Tachyarrhythmia may occur at sites of abnormal myocardium or fibrotic tissue. Over time, tachyarrhythmias that develop with re-entrant arrhythmias develop into bradyarrhythmia or asystoles and cause heart blocks. Another reason is the dissection of the great vessels developing in Marfan syndrome. The causes of death in young athletes vary even according to the regions in which they live. CAD is considered to be one of the most common causes observed among athletes aged >35 years (6).

The mechanism of SCD due to CAD could not be fully understood even the process resulted to ischemic ventricular arrhythmia. Among possible mechanisms are sympathetic activation (which leads to vulnerable myocardial ischemia and thus, arrhythmia), electrolyte-related and metabolic factors (long runs may create imbalance, and most deaths occur in the last quarter of marathon, which might be caused by a heat-stroke), hemodynamic effects of hemostatic system activation, and vulnerable coronary plaques (plaque ruptures, hemostasis, and thrombosis) (2).

In nonstructural heart diseases, mostly heritable rhythm disorders (e.g., long QT syndrome, Brugada syndrome, and catecholaminergic polymorphic ventricular tachycardia) are considered to be responsible. In structurally normal hearts, arrhythmia arises because of trauma or is idiopathic. For example, Commotio cordis emerges because of a blow to the chest. Cardiac hypertrophy or myocarditis was found in the autopsy when a cause could not be detected in idiopathic cases. Also, the use of androgens for doping purposes should not be overlooked (6, 7).

Even though the use of doping in master athletes is not expected, accidental use still occurs. In particular, it is possible to mention three different agents, which have negative effects on the heart and circulatory system. These are androgens, growth factor (GF), and erythropoietin. The effects of various agents are shown in Table I (11, 12).

Different considerations have been made while screening for the condition that causes SCD. When attempting to detect structural abnormalities in the scans, difficulties are encountered for idiopathic cases (6).

Although pre-accession assessment in sports is routinely performed in many countries, its variations still exist. In some countries, only anamnesis is performed without the need for ECG, whereas in other countries, ECG is routinely assessed at scans. However, some countries, such as Denmark, do not perform scans during sports because of the low incidence of SCD (13).

It is obvious that millions of athletes must be screened. However, the incidence of congenital heart diseases in the athletic population is between 0.2% and 0.3%. In rare cases, false positivity is significantly higher. In this scope, one needs 499 extra screenings to detect hypertrophic cardiomyopathy, occurring once in every 500 athletes. This situation will result in specific costs in addition to the workload to the health system (6).

Taking into account similar findings, guides that suggest screening of young athletes have been developed. While the American Heart Association (AHA) recommends a scan solely based on anamnesis and physical examination, the European Heart Association (ESC) additionally recommends ECG (14).

In a study conducted in our country, it was understood that a questionnaire form and physical examination can give successful results during athlete examinations (15). According to the circulation of the Ministry of Health of the Republic of Turkey numbered 2014/29, dated September 24, 2014, and the circulation of the Ministry of Youth and Sports numbered 2014/12523, dated November 14, 2014, the use of Annex 6 Form is recommended for athletes' examination report. The questions in Annex 6 Form match certain questions in the guide.

In 2001, AHA published some recommendations for this risk group (Master Athletes, Athletes 35 and over) (6, 16). Accordingly, 12 points should be taken into account during a complete anamnesis and physical examination.

TABLE I. The effects of sports efficiency-promoting agents on the heart (12)

Substance	HT	Arrhythmias	LVH	CHD	MI	CHF	SCD
Anabolic Androgens	+	+	+	+	+	+	+
HCG		+	+			+	+
Erythropoietin	+					+	
β ₂ agonist		+			+	+	+
Diuretics		+					
Amphetamine	+	+			+	+	+
Cocaine	+	+		+	+	+	+
Ephedrine	+	+		+	+		+
Narcotics							+
Cannabinoids		+			+		+
Glucocorticoids	+			+			
Alcohol	+	+			+	+	+

* total sensitivity was calculated by the number of sensitive organisms/total organisms (47)

Those with a mid-high-level of cardiovascular risk profile should undergo the exercise stress test. Risk profile for males aged >40 years and females aged >50 years or those postmenopausal include having one or more risk factors such as hypercholesterolemia or dyslipidemia, hypertension, cigarette smoking, DM, MI narcosis, or loss of first-degree relative < 60 years.

An overload stress test may also be performed irrespective of other risk factors in patients with CAD history or those aged ≥65 years. There is a limited contribution of ECG to examinations in terms of CAD. However, it could help in athletes over 40 years to detect a previous MI or hypertrophic cardiomyopathy or other rare rhythm disorders.

Echocardiography is engaged in the second phase of the diagnostic process (6, 17, 18).

Asymptomatic athletes have been mentioned above. Early signs of SCD are also worth mentioning.

In particular, those who do not survive SCD are reported to be asymptomatic in general before the event. Survivors do not remember complaints before the competition because of post-resuscitation amnesia (7).

In a community-based study from 2002 to 2012, it was found that 430 (51%) of 839 cases had stimulant complaints of SCD beginning four weeks ago (19).

It has been reported that 80% of the cases complained approximately an hour before the marathon and 34% complained approximately a day (24h) before the marathon. Chest pain (46%) and dyspnea (18%) were among the most frequently reported complaints. Therefore, athletes who have developed symptoms recently should be careful and use necessary medical services (7).

Risk factors of SCD are similar to those of CAD. In addition, psychosocial factors, such as CRP elevation, excessive alcohol consumption, and stress, increase the risk, whereas long-chain n-3 polyunsaturated fatty acids reduce the risk (6, 7).

In general, positive effects of sports on health are well-known, but it is also known that loadings exceeding 11 MET-h/week have no health benefits (20).

In addition, loading-related cardiac troponin elevations, myocardial fibrosis, cardiac dysfunction, arrhythmias, coronary artery calcifications, and increased cardiovascular morbidity and mortality have been reported at high levels (20). However, in runners, troponin elevations are thought to be physiologically independent of ischemia (21). Cardiac dysfunction is mild and disappears 48 h after the loading (22). The issue of the development of atrial fibrillation risk in sportsmen is controversial. It is understood that there is a U-type risk increase for the development of atrial fibrillation. While low and high loads develop atrial fibrillation, moderate loads impede the development of atrial (23). In spite of positive effects of regular running, it was observed that coronary calcification scores are high even in marathon runners (24). Nevertheless, it is debated that findings on the effects of extreme sports on increased cardiovascular disease risk are not mature yet (20).

A review on the approach of master athletes by Chugh et al. (2) is presented in Figure 1.

CAD is an important risk factor in terms of SCD in master athletes (25). In this respect, the following points should be considered for high-risk athletes, within the framework of the proposals of AHA, American Sports Medicine College, and European Cardiovascular Rehabilitation Association Guidelines (25):

- a. Risk of CAD in 10 years (Framingham Risk Score)
- b. Total cholesterol level > 320 mg/dl or LDL-cholesterol > 240 mg/dL
- c. DM with microalbuminuria
- d. A family history of SCD or early CAD in first-degree relatives (aged < 50 years)
- e. Body mass index > 28 kg/m²

Warning signs suggested for young athletes, but which are also valid for master athletes, are presented below (26, 27):

- a. Chest pain or discomfort with loading
- b. Disproportionate dyspnea with loading, unexplained dyspnea, or fatigue due to loading
- c. Palpitation
- d. A syncope or close syncope, particularly due to loading
- e. Hypertension history
- f. Presence of a known cardiac murmur
- g. Personal or family unexplained drowning or traffic accident
- h. Family history of SCD

If we address the three-staged scanning method (Figure 1, 2) in detail, the risk assessment is primarily done in the first step. Risk factors mentioned above are taken into consideration. In our country, the Annex Form 6, which the Ministry of Health and the Ministry of Sports has suggested to family physicians, mostly contains these questions. The second stage of the evaluation is conducted subsequently for the athlete who has a positive result for risk assessment. Here a detailed clinical history is taken:

- Family history and backgrounds are handled. A positive response in terms of MI, cardiac surgery, cardiac catheterization, PTCA, pacemakers, heart valve disease, heart failure, heart transplantation, and congenital heart disease are to be considered.
- A more detailed medical examination is required for complaints, such as chest discomfort due to loading, unreasonable shortness of breath, dizziness, blackouts or taking heart medications, and not being able to find an explanation for other complaints (e.g., muscle pain)

If two of the following cardiovascular risk factors are present, then a more detailed medical examination is needed:

- >45-years-old male
- >55-years-old female, those with a history of hysterectomy, or those who are menopausal smoking history
- Blood pressure > 140/90 mmHg
- Blood pressure unknown
- Cholesterol > 240 mg/dL
- Having a first-degree male relative < 55-years-old or female relative < 65-years-old who has had MI previously

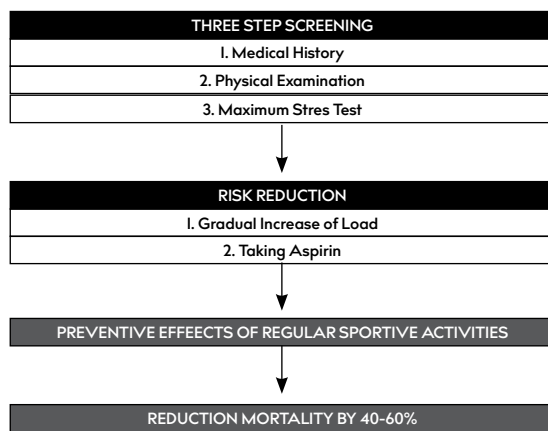


FIGURE I. Balance between SCD Risk and Benefits of Sports (2)
SCD: sudden cardiac death

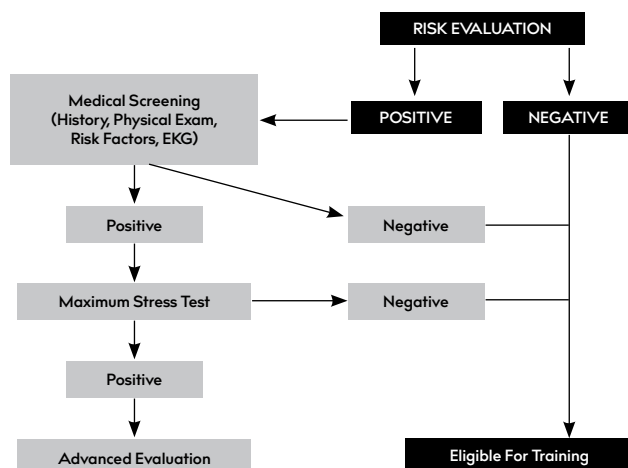


FIGURE 2. Evaluation Algorithm of Master Athletes in Terms of CAD Disease (Three-Step Scanning) (2, 28)
CAD: coronary heart disease

- Having diabetes or using medication for diabetes
- Inactive lifestyle (physical activity for >30 min/3 days/week)

If there are no positive responses to the above questions, the athlete may start training immediately (2, 28).

Detailed physical examination and a 10-year absolute CAD risk are calculated. The risks expressed in Figure I are also studied. The following suggestions are recommended according to Chugh et al. (2):

- Peak loading test must be performed if there is a high risk. If this is not possible, single photon emission CT or stress echocardiography should be performed. This is particularly for individuals with a capacity of <2 MET-h/week.
- Routine stress testing in healthy athletes is not recommended. The use of ECG and echocardiography in accordance with the requirements in addition to the examination will lead to the emergence of previously unknown or unexplained structural heart problems.
- On the other hand, the effort test is not sufficient for revealing subclinical CAD. Plaque ruptures causing

SCD are caused by tightness of non-critical stenosis. Because of this, radiodiagnostic imaging of plaques is important, but it is not possible to put them into practice in terms of cost effectiveness.

- Reducing risks of elderly athletes is as important as health screenings. Slow and gradual training of beginner athletes will increase safety.
- If hypercholesterolemia is present, it is treated according to standard treatment regimens.
- The use of low-dose acetylsalicylate (75-100 mg) is recommended.

In conclusion, it is a fact that the risk of SCOR due to spore in elderly athletes is increased. As the population increases, the population at risk will also increase.

CAD is the leading cause of SCD. Among athletes who participate in sports, those who are new or less trained are particularly at risk of SCD. For this reason, master athletes as well as those with lesser training, particularly in challenging conditions, must be subjected to a three-staged scanning program. Even the three-step screening covers several guides, its validity and reliability should be determined with extensive studies (2). It is not easy to predict the risk of plaque rupture, and this group should be detected in collaboration with a cardiologist by using a cost-effective approach. The use of acetylsalicylic acid before the race is promising to reduce the lethality of SCD during the competition (29). Apart from this, bystander CPR practices might be useful during marathon runs (1).

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - H.Y., İ.A., G.G.; Literature Search - H.Y., İ.A., G.G.; Writing - H.Y., İ.A., G.G.; Critical Reviews - H.Y., İ.A., G.G.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

REFERENCES

1. Cohen SI, Ellis ER. Death and near death from cardiac arrest during the Boston Marathon. *Pacing Clin Electrophysiol* 2012; 35: 241-4. [CrossRef]
2. Chugh SS, Weiss JB. Sudden cardiac death in the older athlete. *J Am Coll Cardiol* 2015; 65: 493-502. [CrossRef]
3. Marijon E, Uy-Evanado A, Reinier K, Teodorescu C, Narayanan K, Jouven X, et al. Sudden cardiac arrest during sports activity in middle age. *Circulation* 2015; 131: 1384-91. [CrossRef]
4. Waite O, Smith A, Madge L, Spring H, Noret N. Sudden cardiac death in marathons: a systematic review. *Phys Sportsmed* 2016; 44: 79-84. [CrossRef]
5. Gerardin B, Collet JP, Mustafic H, Bellemain-Appaix A, Benamer H, Monsegu J, et al. Registry on acute cardiovascular events during endurance running races: the prospective RACE Paris registry. *Eur Heart J* 2016; 37: 2531-41. [CrossRef]
6. UpToDate: Risk of sudden cardiac death in athletes. Available at: <https://www.uptodate.com/contents/risk-of-sudden-cardiac-death-in-athletes>. Date of Access: 11.04.2017.
7. UpToDate: Overview of sudden cardiac arrest and sudden cardiac death. Available at: <https://www.uptodate.com/contents/overview-of-sudden-cardiac-arrest-and-sudden-cardiac-death>. Date of Access: 11.04.2017.
8. European Heart Rhythm Association, Heart Rhythm Society, Zipes DP, Camm AJ, Borggrefe M, Buxton AE, et al. ACC/AHA/ESC 2006

- guidelines for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: a report of the American College of Cardiology/American Heart Association Task Force and the European Society of Cardiology Committee for Practice Guidelines (Writing Committee to Develop Guidelines for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death). *J Am Coll Cardiol* 2006; 48: e247-346. [CrossRef]
9. Clearinghouse: Sudden Cardiac Death in Sport. Available at: https://www.clearinghouseforsport.gov.au/knowledge_base/sport_partici.../sport_injuries_and_medical_conditions/sudden_cardiac_death_in_sport. Date of Access: 11.04.2017.
 10. Maron BJ, Poliac LC, Roberts WO. Risk for sudden cardiac death associated with marathon running. *J Am Coll Cardiol* 1996; 28: 428-31. [CrossRef]
 11. Sharma S, Merghani A, Mont L. Exercise and the heart: the good, the bad, and the ugly. *Eur Heart J* 2015; 36: 1445-53. [CrossRef]
 12. Deligiannis A, Björnstad H, Carre F, Heidbüchel H, Kovid E, Panhuyzen-Goedkoop NM, et al. ESC study group of sports cardiology position paper on adverse cardiovascular effects of doping in athletes. *Eur J Cardiovasc Prev Rehabil* 2006; 13: 687-94. [CrossRef]
 13. Maron BJ, Levine BD, Washington RL, Baggish AL, Kovacs RJ, Maron MS, et al. Eligibility and Disqualification Recommendations for Competitive Athletes With Cardiovascular Abnormalities: Task Force 2: Preparticipation Screening for Cardiovascular Disease in Competitive Athletes: A Scientific Statement From the American Heart Association and American College of Cardiology. *Circulation* 2015; 132: e267-72. [CrossRef]
 14. UpToDate: Screening to prevent sudden cardiac death in athletes. Available at: <http://www.uptodate.com/contents/screening-to-prevent-sudden-cardiac-death-in-athletes>. Date of Access: 11.04.2017.
 15. Yaman H, Ozbas H, Toraman F, Yaman A. The use of a standardized pre-participation physical examination form in Turkish adolescent athletes. *Saudi Med J* 2005; 26: 230-3.
 16. Maron BJ, Araujo CG, Thompson PD, Fletcher GD, de Luna AB, Fleg JL, et al. Recommendations for preparticipation screening and the assessment of cardiovascular disease in masters athletes: an advisory for healthcare professionals from the working groups of the world heart federation, the international federation of sports medicine, and the American Heart Association committee on exercise, cardiac rehabilitation, and prevention. *Circulation* 2001; 103: 327-34. [CrossRef]
 17. Abbateamarco JR, Bennett C, Bell AJ, Dunne L, Matsumura ME. Application of pre-participation cardiovascular screening guidelines to novice older runners and endurance athletes. *SAGE Open Med* 2016; 4: 2050312115616136. [CrossRef]
 18. Lavie CJ, Harmon KG. Routine ECG Screening of Young Athletes: Can This Strategy Ever Be Cost Effective? *J Am Coll Cardiol* 2016; 68: 712-4. [CrossRef]
 19. Marijon E, Uy-Evanado A, Dumas F, Karam N, Reinier K, Teodorescu C, et al. Warning Symptoms Are Associated With Survival From Sudden Cardiac Arrest. *Ann Intern Med* 2016; 164: 23-9. [CrossRef]
 20. Eijssvogels TM, Molossi S, Lee DC, Emery MS, Thompson PD. Exercise at the Extremes: The Amount of Exercise to Reduce Cardiovascular Events. *J Am Coll Cardiol* 2016; 67: 316-29. [CrossRef]
 21. Shave R, Baggish A, George K, Wood M, Scharhag J, Whyte G, et al. Exercise-induced cardiac troponin elevation: evidence, mechanisms, and implications. *J Am Coll Cardiol*. 2010; 56: 169-76. [CrossRef]
 22. McGavock JM, Warburton DE, Taylor D, Welsh RC, Quinney HA, Haykowsky MJ. The effects of prolonged strenuous exercise on left ventricular function: a brief review. *Heart Lung* 2002; 31: 279-92. [CrossRef]
 23. Mozaffarian D, Furberg CD, Psaty BM, Siscovick D. Physical activity and study. *Circulation* 2008; 118: 800-7. [CrossRef]
 24. Möhlenkamp S, Lehmann N, Breuckmann F, Bröcker-Preuss M, Nassenstein K, Halle M, et al. Running: the risk of coronary events : Prevalence and prognostic relevance of coronary atherosclerosis in marathon runners. *Eur Heart J* 2008; 29: 1903-10. [CrossRef]
 25. Schmied C, Borjesson M. Sudden cardiac death in athletes. *J Intern Med* 2014; 275: 93-103. [CrossRef]
 26. Sheikh N, Sharma S. Overview of sudden cardiac death in young athletes. *Phys Sportsmed* 2011; 39: 22-36. [CrossRef]
 27. D'Silva A, Sharma S. Exercise, the athlete's heart, and sudden cardiac death. *Phys Sportsmed* 2014; 42: 100-13. [CrossRef]
 28. Borjesson M, Urhausen A, Kovid E, Dugmore D, Sharma S, Halle M, et al. Cardiovascular evaluation of middle-aged/ senior individuals engaged in leisure-time sport activities: position stand from the sections of exercise physiology and sports cardiology of the European Association of Cardiovascular Prevention and Rehabilitation. *Eur J Cardiovasc Prev Rehabil* 2011; 18: 446-58. [CrossRef]
 29. Siegel AJ. Preventing Acute Cardiac Events during Marathons with Pre- Race Aspirin. *Int J Clin Cardiol* 2015; 2: 51. [CrossRef]