

Sudden death and cardiac arrest in marathon runners: incidence rates and causes

Morte súbita e parada cardíaca em corredores de maratona: taxas de incidência e causas

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ABSTRACT

Background: The marathon race is an aerobic sport that requires high training volume. Marathon runners may eventually be exposed to unfavorable environmental conditions associated with changes in blood volume and hydration level that may increase the risk of cardiac arrhythmias that can cause cardiac arrest and sudden death. **Objective:** To identify the existing life risks for marathon runners related to the occurrences of sudden death and cardiac arrest and the most prevalent causes of these events. **Methods:** Integrative literature review of descriptive-qualitative nature in the databases: Google, Academic Google, Medline, Scielo and Pubmed. **Results:** Sudden death incidence rates ranged from 0.58 to 2.0 per 100.000 runners while cardiac arrest rates ranged from 1.01 to 2.6 per 100.000 runners being men most susceptible to these events. Among the causes of sudden death and cardiac arrest, studies indicate that in older athletes (age > 45 years) coronary artery disease (CAD) is the most prevalent and in younger athletes (age < 45 years) structural and congenital causes are the most common as hypertrophic cardiomyopathy. Most of the events of sudden death and cardiac arrest occurred in the last quartile of the race or after the finish line. **Conclusion:** The risks of sudden death and cardiac arrest in marathons are low and higher in men being coronary artery disease and hypertrophic cardiomyopathy the most prevalent causes of these events.

Key-words: Sudden, Death, Sudden cardiac death, Hypertrophic cardiomyopathy, Exercise, Heart arrest.

RESUMO

Introdução: A corrida de maratona é um esporte aeróbico que requer treinamento de alto volume. Corredores de maratona podem eventualmente estar expostos a condições ambientais desfavoráveis associadas a alterações no volume sanguíneo e nível de hidratação que podem aumentar o risco de ocorrência de arritmias cardíacas que podem provocar parada cardíaca e morte súbita. **Objetivo:** Identificar os riscos à vida existentes para os corredores de maratona relacionados às ocorrências de morte súbita e parada cardíaca e as causas mais prevalentes destes eventos. **Métodos:** Revisão integrativa, de natureza descritivo-qualitativa nas bases de dados: Google, Google Acadêmico, Medline, Scielo e Pubmed. **Resultados:** As taxas de incidência de morte súbita variaram entre 0,58 a 2,0 por 100.000 corredores enquanto as taxas de parada cardíaca variaram de 1,01 a 2,6 por 100.000 corredores sendo os homens mais susceptíveis a estes eventos. Entre as causas de morte súbita e parada cardíaca os estudos apontam que em atletas mais idosos (idade > 45 anos) a doença arterial coronariana é a mais prevalente e em atletas mais jovens (idade < 45 anos) causas estruturais e congênitas são as mais comuns a exemplo de cardiomiopatia hipertrófica. A maior parte dos eventos de morte súbita e parada cardíaca ocorreram no último quartil da prova ou após a linha de chegada. **Conclusão:** Os riscos de morte súbita e parada cardíaca em maratonas são baixos e maiores em homens, sendo a doença arterial coronariana e cardiomiopatia hipertrófica as causas mais prevalentes destes eventos.

Palavras-chave: Morte súbita, Morte súbita cardíaca, Cardiomiopatia hipertrófica, Exercício, Parada cardíaca.

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Introduction

Numerous scientific studies establish the close relationship between physical exercise, physical and mental health and the consequent improvement of longevity. The marathon run (42,2 km) induces the individual to physiological adaptations that lead to the reduction of the risks related to systemic arterial hypertension, dyslipidaemias and diabetes. Additionally, individuals who regularly practice running activity benefit from lower rates of mortality or disability [1].

In history, the origin of the marathon race is depicted from an epic event when in Greece the soldier Pheidippides in 490 BC ran the 40 km from the Marathon plain to Athens to announce the victory of the Athenian army over the Persians, to then collapse and die of exhaustion [1]. Today, more than 1,298,588 runners participate in marathons around the world each year [2].

However, marathon runners may eventually be exposed to unfavorable environmental conditions associated with changes in blood volume and hydration level that may increase the risk of cardiac arrhythmias, which lead to events such as Cardiac Arrest (CA) or Sudden Death (SD) [3].

Sudden death in marathons is an impacting event, with great media repercussions nowadays.[4]. SD is considered during exercise, a dramatic, atraumatic and unexpected condition that affects apparently healthy people, occurring during or up to two hours after the practice of sports activity [6]. On the other hand, CA is defined by an unconscious state with absence of spontaneous breathing and pulse, attested by a medical professional [7]. In a period of 27 years (1980-2006) there were 1,886 fatalities of sudden death in athletes in the United States [5].

Due to the importance of the theme, this integrative literature review aims to identify the main causes of Sudden Death (SD) and Cardiac Arrest (CA), in addition to pointing out the incidence rates of these events in marathon runners.

Methods

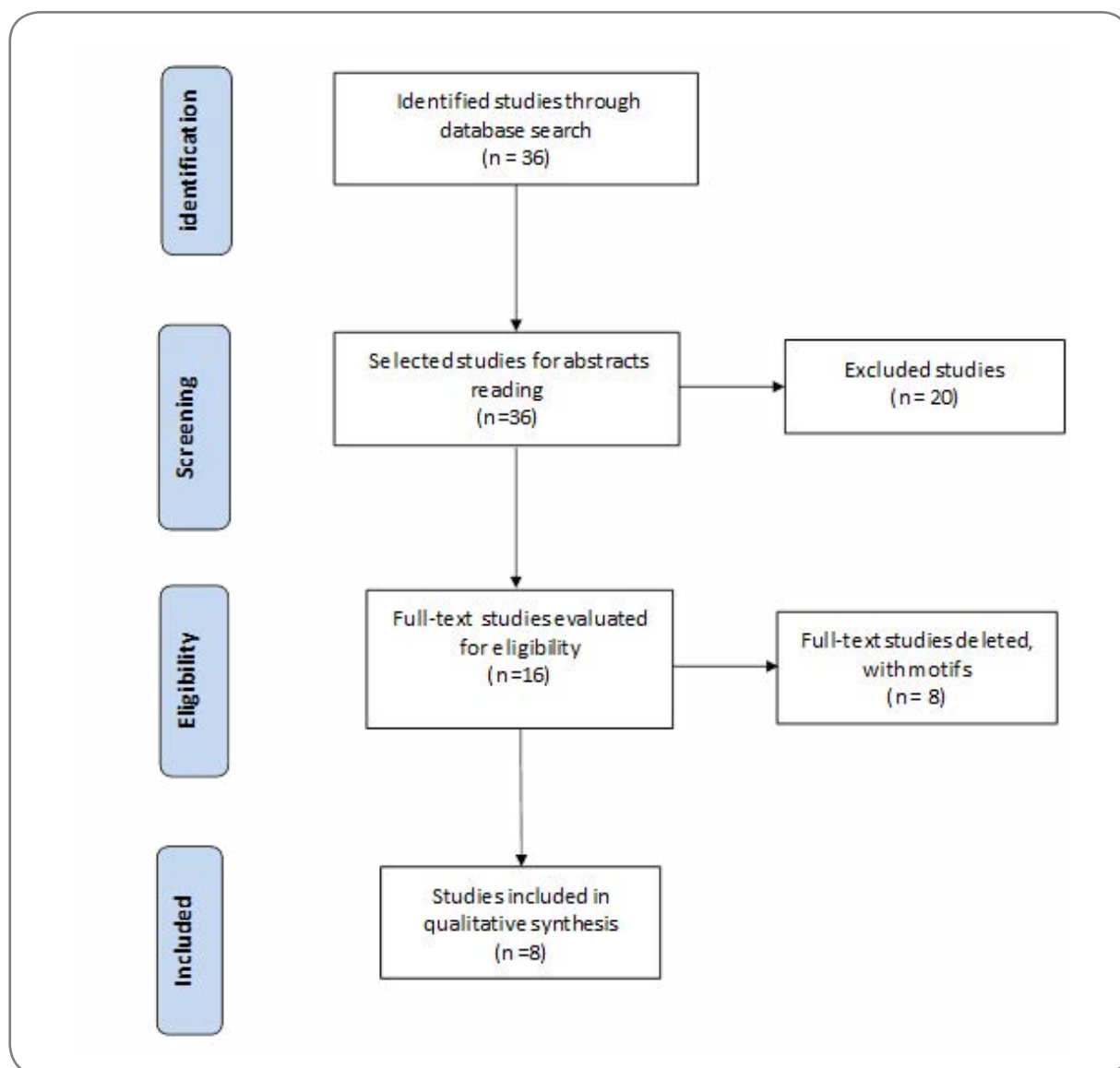
The present work consists of a integrative literature review, of descriptive-qualitative nature. The following databases were used to search for scientific articles: Google, Google Scholar, Scielo and PubMed.

For the search of the scientific articles in these databases, the following keywords were used in Portuguese and English: Sudden Death, Sudden Cardiac Death, Hypertrophic Cardiomyopathy, Exercise, Cardiac Arrest.

Inclusion criteria: Observational studies that evaluated the occurrences and calculated the incidence rates of SD and CA in marathon races and studies that identified the causes of the occurrence of these events. Exclusion criteria were: studies that evaluated runners with identified heart disease, studies that did not contain the frequencies of SD and CA, and systematic reviews.

Results

After the search, 36 scientific articles were tracked. After reading the titles, 20 were excluded and then the abstracts were read. Eight studies were selected after reading the abstracts. Figure 1 illustrates the flowchart of screening and selection process of the studies included in this review.



Source: The authors

Figure 1 - Flowchart of screening and selection of studies.

Eight studies evaluating the incidence rate of CA and SD in marathons were selected. Six articles were produced in the United States [1,3,4,7,8,9], one in Sweden [10], and one in England [11]. The results on the occurrences and incidence rates of SD and CA are described in Table I.

All articles, considering the number of outcomes, calculated the incidence rates of CA and SD. The incidence rates of SD in the studies ranged from 0.58 to 2.0 per 100,000 runners, while the incidence rates of CA in the studies ranged from 1.01 to 2.6 per 100,000 runners. Studies by Mathews *et al.* [1] and Roberts, Roberts and Lunos [13] show that men are more susceptible to SD events (71% and 73%) than women (27% and 30%) respectively. Some studies have calculated incidence rates for both sexes [1,3,7]. The study by Siebra and Feitosa-Filho [10] did not record the occurrence of marathon outcomes for the period analyzed and therefore no incidence rates for this study were calculated.

Table II lists the causes of SD reported in the studies. Only the study of Kim *et al.* [9] did not report the cause of SD and therefore did not compose this table.

Table I - Sudden death and cardiac arrest incidence rates in marathons.

Author	Period	Population	Ocorrence SD			Ocorrence CA			Incidence rate SD			Incidence rate CA		
			M	W	T	M	W	T	M	W	T	M	W	T
Mathews et al. (2012)	2000-2009	3.718.336	22	6	28				0.98	0.41	0.75			
Redelmeier e Greenwald (2007)	1975-2004	3.292.268			26						0.80			
Webner et al. (2012)	1976-2009	1.710.052			10			30			0.58			1.75
Maron et al. (1996)	1976-1994	215.413	3	1	4						2.00			
Roberts, Roberts e Lunos (2012)	1982-2009	548.092	6	1	7	13	1	14	1.60	0.60		3.40	0.60	2.60
Pedoe (2007)	1981-2007	650.000	8		8						1.53			
Kim et al. (2012)	2000-2010	3.949.000				34	6	40			0.63	1.41		1.01

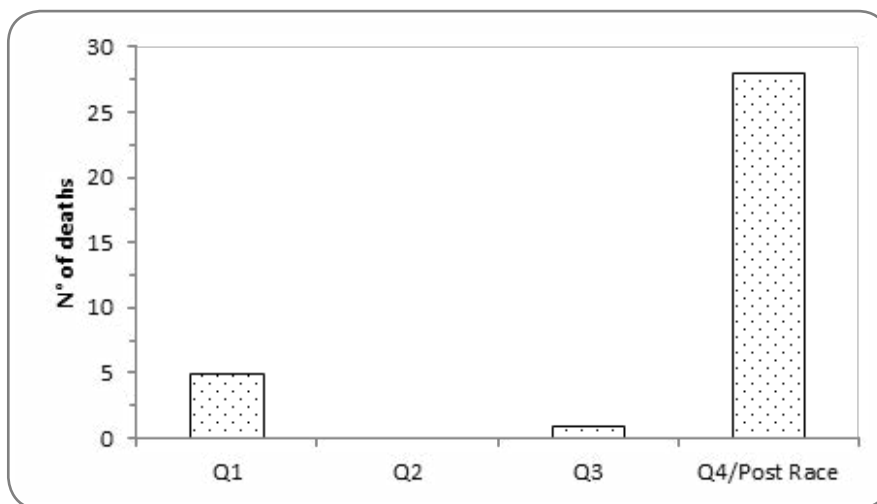
M = Men; W = Women; T =Total; SD = Sudden Death; CA = Cardiac Arrest; Incidence Rate = xx/100,000 runners; Source: the authors.

Table II - Causes of sudden death in marathons.

Cause	Mathews (N=28)	Redelmeier (N=28)	Webner (N=10)	Maron (N=4)	Roberts (N=7)	Pedoe (N=10)	Total (N=87)
Coronary Artery Disease	13	21	7	3	6	5	55
Cardiac Arrest	4						4
Hyponatremia	2						2
Hypertrophic Cardiomyopathy	2					3	5
Valvular Anomaly	2						2
Heart Failure	1						1
Hyperthermia	1	1					2
Cerebral Aneurysm	1						1
Coronary Fibromuscular Dysplasia	1						1
Coronary Artery Abnormality*		2	1	1	1		5
Cardiac Arrhythmia	1						1
Electrolyte Imbalance		4					4
Subarachnoid Hemorrhage						2	2
Unknown Cause			2				2

(*):Coronary artery abnormality refers to congenital anomalies including origin, path, or its structure; Source: the authors.

The studies by Maron, Poliac and Roberts [3] and Roberts, Roberts and Lunos [7] that analyzed the SD and CA data in approximately 4,000,000 marathon runners in the United States found that the majority of the cases of SD recorded, approximately 80%, occurred in the last quartile of the race, equivalent to the last 12 km or shortly after arrival (Figure 2). The other studies were not considered because there was overlapping of marathons and analyzed periods, thus avoiding the calculation of duplicate data.



Source: the authors

Figure 2 - Distribution of occurrence of SD (Q=10 km).

Discussion

The studies show that the incidence rates of SD in marathons ranges from 0.58 to 2.00 and CA ranges from 1.01 to 2.60 per 100,000 runners, considering the total period analysed from 1975 to 2010 [1,3,4,7,8,9,11]. However, considering the studies that evaluated half marathon races (21.1 km), the SD rate is lower, ranging between 0.27-0.35 per 100,000 runners [9,10,12]. Regarding the causes of SD and CA, the studies [1,3] indicate that in older athletes (age > 45 years) coronary artery disease (CAD) is the most prevalent and in younger athletes (age < 45 years) structural and congenital causes are the most common, such as hypertrophic cardiomyopathy [1,3].

Regarding gender, the studies by Roberts, Roberts and Lunos [7] indicate that in marathons men are more vulnerable to CA and SD than women, corresponding to a ratio of 6:1, which is compatible with the incidence of coronary artery disease (CAD) in men, which is twice that observed for women [1]. Additionally, the study by Harris *et al.* [13] corroborates this prevalence, indicating a combined incidence rate of SD and CA in triathlon of 2.4 and 0.74 per 100,000 athletes, respectively for men and women. Another factor pointed out that may explain the lower occurrence of SD and CA in females is that women who run marathons are younger than men. The proportion of age under 40 years is 62% for women and 48% for men [7].

There is a decreasing trend in the incidence rates of SD presented in the most recent studies [1,9], for the period 2000-2010 when compared to the older studies [3]. This fact is probably due to the improvement of the emergency plans of basic life support for runners, adopted by most large marathons that currently rely on the massive use, along the way, of emergency teams endowed with automatic external defibrillators (AED) [14]. According to the study by Roberts and Maron [14], the proximity of an AED is the major determinant of survival for a runner who suffered a

cardiac arrest at some point on the race, which is in line with the study by Tomoya *et al.* [15] conducted in Japan that points to an increase in the survival rate in runners after cardiac arrest from 47% to 95% when an AED is used.

The studies [3,7] whose data was analyzed were represented in Figure 2 showed that most of the SD events occurred in the last quartile of the race or just after the finish line. This fact indicates the need for an increase in the density of basic life support resources for runners over the last kilometers in order to ensure greater effectiveness in emergency care.

Some issues should be considered in the critical analysis of the data presented here: All studies analyzed were retrospective in nature, since there was no general record of SD and CA events in marathons at the time of publication. The information was obtained by the authors through questionnaires sent to race directors or in research on the internet and print media, which can lead to errors regarding the actual number of events that occurred with consequent underestimation of the calculated incidence rates; Some studies used for the calculation of the incidence rates of CA and SD the number of race participants and in others the number of finishers, which is lower due to dropouts throughout the race, which can lead to overestimation of the incidence rate of SD and CA for these studies when using the latter population; Some studies did not report the criteria for calculating incidence rates and did not calculate the statistical confidence interval for these rates; Some studies have shown overlapping research periods and races performed which may have led to duplicate data of SD and CA events inducing inconsistency in the total number of events occurred.

Although SD and CA are rare events in marathon races, due to their severity and consequent threat to the athlete's life, they require the race organizers to implement an efficient and agile system of basic life support and medical emergency with massive use of Automatic External Defibrillators - AED, supporting the entire course of the race, which significantly increases the survival rate of the athlete in CA events.

Finally, it is essential that all athletes who run marathons, professionals involved in the prescription of exercises and race organizers be aware of the risks involved in this type of competition in order to adopt and guide their actions, in their scope of action, in order to minimize the risks of occurrences of CA and SD.

Conclusion

Based on the data presented in this study, it is concluded that in marathons the incidence rates of SD ranging from 0.58 to 2.00 and CA ranging from 1.01 to 2.60 per 100,000 runners. In runners over the age of 45 years, coronary artery disease is the most prevalent cause of death, while in runners under the age of 45 years, hypertrophic cardiomyopathy is the main cause of CA and SD.

Moreover, men are more likely than women to events of CA and SD and the last 10 km of the marathon course is the race interval where more than 80% of the events of SD and CA occur. The use of AED to care for these victims can reduce the chance of death of these runners by 95%.

Potential conflict of interest

No conflict of interest with potential relevant to this article has been reported.

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Academic link

There is no link between this study and graduate programs.

Author's contributions

Conception and design of the research: Araújo OAST, Tenório MCC. Data collection: Araújo OAST, Tenório MCC. Data analysis and interpretation: Araújo OAST, Tenório MCC. Statistical analysis: Araújo OAST, Tenório MCC. Obtaining financing: None. Writing of the manuscript: Araújo OAST, Tenório MCC. Critical review of the manuscript for important intellectual content: Araújo OAST, Tenório MCC.

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