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Do Brazilian Olympic athletes live longer than the general population? A retrospective cohort study

Os atletas olímpicos brasileiros vivem mais que a população em geral? Estudo de coorte retrospectivo

¿Los atletas olímpicos brasileños viven más que la población general? Un estudio de cohorte retrospectivo

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Abstract *We investigated if Brazilian Olympic athletes live longer than the general population, and if there are differences between the types of sport. This is a retrospective cohort study with secondary data analysis. Data from Brazilian athletes of both sexes were included, from the 7th edition (1920) to the 25th edition (1992) of the Modern Olympic Games. Details of sex, date of birth, date of death, and sport competed were recorded when available. Comparisons were made between athletes vs. age-matched controls from the general population; and between sport types (strength/power [SP] vs. endurance/mixed [EM]). Brazilian Olympic athletes live approx. 8 years longer than expected for the age matched general population. However, there were no differences in lifespan between SP (68.8 years) vs. EM (68.9 years) athletes (p>0.05). Brazilian Olympic athletes live longer than expected for the general population. However, there are no differences between athletes from different sport types.*
Key words *Athletes, Longevity, Life expectancy, Physical activity, Sports*

Resumo *Investigamos se os atletas olímpicos brasileiros vivem mais que a população em geral e se existem diferenças entre os tipos de esporte. Trata-se de um estudo de coorte retrospectivo com análise de dados secundários. Foram incluídos dados de atletas brasileiros de ambos os sexos, desde a 7ª edição (1920) até a 25ª edição (1992) dos Jogos Olímpicos Modernos. Detalhes sobre o sexo, data de nascimento, data de falecimento e esporte praticado foram registrados quando disponíveis. Foram feitas comparações entre atletas e controles de mesma idade da população em geral; e entre tipos de esporte (força/potência [SP] vs. resistência/misto [EM]). Os atletas olímpicos brasileiros vivem aprox. 8 anos a mais do que o esperado para a população geral correspondente à idade. No entanto, não houve diferenças na expectativa de vida entre atletas SP (68,8 anos) vs. EM (68,9 anos) (p>0,05). Os atletas olímpicos brasileiros vivem mais que o esperado pela população em geral. No entanto, não há diferenças entre atletas de diferentes modalidades esportivas.*
Palavras-chave *Atletas, Longevidade, Expectativa de vida, Atividade física, Esportes*

Resumen *Investigamos si los atletas olímpicos brasileños viven más que la población general y si existen diferencias entre los deportes. Este estudio de cohorte retrospectivo se realizó con análisis de datos secundarios. Se incluyeron datos de atletas brasileños de ambos sexos, desde la 7.ª edición (1920) hasta la 25.ª edición (1992) de los Juegos Olímpicos Modernos. Registramos detalles de género, fecha de nacimiento, fecha de defunción y deporte en el que compitieron, cuando estaban disponibles. Comparamos atletas con controles de la misma edad de la población general; y entre tipos de deporte (fuerza/potencia [FP] vs. resistencia/mixto [RM]). Los atletas olímpicos brasileños viven aproximadamente ocho años más de lo esperado para la población general de la misma edad. Sin embargo, no hubo diferencias en la esperanza de vida entre los atletas FP (68,8 años) vs. RM (68,9 años) (p>0,05). Los atletas olímpicos brasileños viven más de lo esperado para la población general. Sin embargo, no hay diferencias entre atletas de diferentes tipos de deporte.*
Palabras clave *Atletas, Longevidad, Esperanza de vida, Actividad física, Deportes*

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Introduction

A dichotomous perspective exists between the beneficial effects of physical exercise and the risks of strenuous efforts. Prospective studies have demonstrated that additional increases in exercise, starting from moderate levels i.e., 3600 metabolic equivalents (MET) per minutes/week[1] can be beneficial for health and longevity, thus suggesting that the more physical activity practiced, the better these outcomes[2]. However, other studies have identified a greater cardiac risk related to frequent strenuous efforts[3].

Athletes are a select population who may yield insights into the associations between high levels of physical training over time and longevity. In the last two decades, an increasing number of studies have addressed the question of whether elite athletes live longer than the general population[4-10]. The results from the majority of previous studies[4,6-10] confirmed the survival advantage of being an Olympic athlete, regardless of country and sex.

However, it may be premature to make conclusions about the survival advantage of being an Olympic athlete in all countries, since the majority of studies on this topic were conducted with athletes from developed countries[5,6]. The four reviews on this topic Teramoto and Bungum[9], Garatachea *et al.*[6], Lemez and Baker[7], and Runacres *et al.*[8], all included studies that analyzed samples of Olympians from Europe, North America, Oceania, and Asia, such as the United States (US), France, Italy, Belgium, Norway, Sweden, Finland, New Zealand, the Netherlands, Germany, Japan, Poland, and the United Kingdom (UK). As far as we know, no studies have been performed on this topic with athletes from developing countries. Despite being the 12th largest economy in the World in 2020 (according to the Austin Rating), Brazil has a lower socioeconomic profile and life expectancy when compared to countries from Europe and the US[11]. This could be an important consideration, as studies performed in Brazil may clarify whether the expected advantage of being an Olympian is influenced by the social, economic, geographical, and cultural factors of the country, when compared to developed countries.

On the other hand, it should be noted that lower mortality rates were observed for endurance but not for power athletes in some previous studies[7-10], and it is unknown whether this pattern will be observed in Brazilian Olympians, given the important differences in sports training methods and cultures between countries. Therefore, differences in longevity in terms of sport modality remain to be elucidated in developing countries with different socioeconomic and cultural contexts.

Thus, the aims of this study were: (1) to investigate whether former Brazilian Olympic athletes live longer than an age matched sample of the general population; and (2) to describe whether the sport type is related to greater longevity.

Methods

This is a retrospective cohort study of Brazilian male and female Olympic athletes. We used publicly available data from the Brazilian Olympic Committee (COB) website (https://www.cob.org.br/) to identify all the Brazilian women and men who participated, at least once, in the Summer Olympic Games between 1920 (Antwerp, Belgium) and 1992 (Barcelona, Spain). The sex, dates of birth and death, date(s) of Olympic Games participation, and sports competed in of all the athletes were obtained from both the COB website and the book: "*Atletas Olímpicos Brasileiros*"[12]. Athletes with a missing date of birth were excluded from the analyses (Figure 1).

No ethical approval was needed. According to the National Health Council (CNS, acronym in Portuguese), Resolution No.

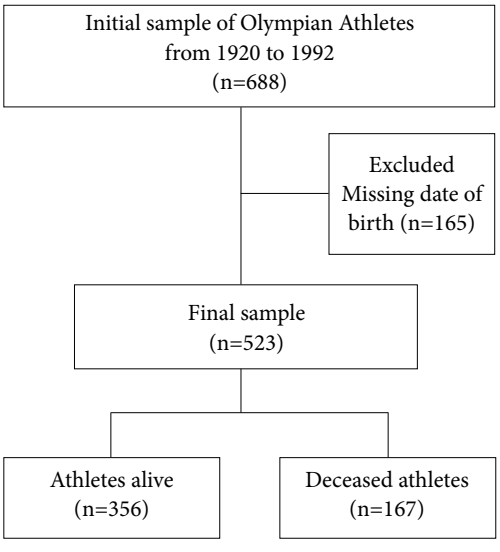

Figure 1. Study flowchart.

Source: Authors.

466/2012 (https://conselho.saude.gov.br/resolucoes/2012/Reso466.pdf), no approval or ethical review by the CEP-CONEP system (Research Ethics Committee - National Research Ethics Commission) was needed as all data are available in the scientific literature and on the COB site. All data were anonymized before use.

The data from the Brazilian population were obtained from the Brazilian Institute of Geography and Statistics (IBGE) life tables (https://doi.org/10.48331/scielodata.13JWWJ).

In our study the athletes were matched by year of birth and age when they participated in the Summer Olympic Games.

For the sport type comparison, the athletes were categorized into two distinct groups: Strength/Power and Endurance/Mixed. The two types of sports are described in Chart 1. A similar criterion has previously been used[8], in which Strength and Power (SP) athletes were those from predominantly anaerobic or technical sports; and Endurance and Mixed (EM) athletes were those from continuous or intermittent sports lasting ≥10 min.

Data were inserted into an Excel spreadsheet and statistical analyses were performed using R software. As the main interest is the years lived by the athlete (T_i), we defined $T_i = F_i - N_i / 365$ as the years lived of the i-th athlete (in years), where N_i is the birth date and F_i is the death date for dead athletes; we set F_i = 31/05/2020 for the living athletes, for $i = 1, ..., n$.

For the analyses, we considered descriptive analysis and an adjusted survival model. In this context, we present the summary measures referring to the athletes' lifetime using a boxplot.

Chart 1. Types of sports and their corresponding categories.

Subgroups (n)	Sport (n)	Categories
SP (n=266)	Swimming (31)	50 m, 100 m freestyle, backstroke, breaststroke, butterfly, and relay
	Track and Field (58)	High jump, long jump, weightlifting, discus throw, hammer throw, 100 m, 200 m
	Sailing (41)	Soling, Star, Tempest and Flying Dutchman
	Judo (11)	Male: 60 kg, 66 kg, 73 kg, 81 kg, 90 kg, 100 kg and +100 kg Female: 48 kg and 72 kg
	Volleyball (39)	Team
	Equestrian (12)	Equestrian dressage, eventing, and jumping
	Artistic gymnastics (1)	Rings, Pommel horse, Parallel bars, Fixed bars, soil, jump, asymmetric bars, and balance beam
	Synchronized swimming (3)	
	Diving (5)	Individual, synchronized, 3 m platform and 3m springboard
	Sport shooting (34)	Rifle, pistol, and target
	Wrestling (2)	Greco-Roman, freestyle and women's fight
	Boxing (22)	Weight: rooster, light, medium, heavy
	Fencing (7)	Sword, rapier, and saber
EM (n=257)	Football (80)	Team
	Rowing (34)	Single Skiff, two without, double skiff, coxed fours, four without, four skiff, eight with, double skiff and lightweight
	Basketball (52)	Team
	Tennis (5)	Single, doubles, mixed, and indoor
	Modern pentathlon (6)	(Team)
	Water polo (13)	(Team)
	Cycling (14)	(BMX, road, track and mountain bike cycling)
	Cross-country (1)	
	Track and Field (22)	(Half marathon, marathon, long distance, 400 m, 800 m, and other modalities)
	Swimming (30)	(400 m, 800 m, 1,500 m freestyle, backstroke, breaststroke, butterfly, and relay)

SP: Strength/Power sports; EM: Endurance/Mixed sports.

Source: Authors.

With the aid of the Akaike Information criterion (AIC) selection criteria, in addition to the Kaplan-Meier curve, a model was formulated to adjust the lifetime of the athletes under analysis. Considering the adjusted model, we calculated how much longer an athlete lives in relation to their compatriots.

As the database is composed of the years lived of dead and alive athletes, for the adjustment of the survival model, we assumed that the longevity of living athletes are right-censored observations of type I[13], which means that our study had a set number of athletes and ended on 31/05/2020 (i.e., before the death of many athletes had occurred). Additionally, we considered that the years lived (T_i) came from a weibull distribution, which showed the lowest value of the AIC criterion. To estimate the parameters, we considered the maximum likelihood method[14].

For comparisons of the life expectancy of Olympic athletes and the general population we present two approaches:

1. Let E_i be the life expectancy of the population in the year in which the *i*-th athlete competed in an Olympiad for the first time and I_i the age at which the athlete competed in an Olympiad for the first time, for $i = 1, ... n$. In this way, we calculated the survival model for the two sport groups, in order to compare the survival of athletes according to the sport they practiced. The log rank test was used to verify the differences in the survival curves between the sport categories;

2. The average lifetime of the athletes (according to their sport category) was compared to the average life expectancy of the age matched general population using t-tests. The alpha level for statistical significance was set at $p<0.05$.

Results

A total of 523 (465 men) Olympian athletes were included in this study, among which 167 had died (32%; 159 men, 8 women) and 354 were alive (68%; 306 men) on May, 31th, 2020 (the study end point). Figure 2 presents the boxplot of the lifetime of deceased and alive athletes. Among the deceased athletes, the shortest lifetime recorded was 28 years and the longest was 104 years, with a median lifetime of 73 years, ranging from 50y (1st Quartile) to 82y (3rd Quartile). Among the living athletes, the shortest and longest lifetimes were 46 and 100 years, respectively, with a median lifetime of 65 years, ranging from 57y (1st Quartile) to 80y (3rd Quartile).

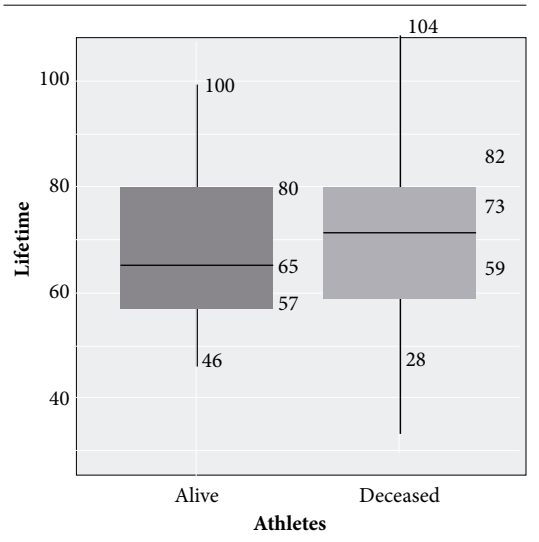

Figure 2. Boxplot representation of the athletes' lifespan.

Source: Authors.

The median lifetime of dead female athletes was greater than that of male athletes. For living athletes, the median lifetime of male athletes was significantly greater than that of female athletes.

Figure 3A shows the Kaplan-Meier survival models with confidence intervals, while Figure 3B shows the survival curves of the Weibull model. There was no difference between the survival of the two groups, according to the log rank test, that is, the estimation indicates a consistently equal survival function between EM and SP athletes.

The average lifespans of SP and EM athletes were 68.8 and 68.9 years, respectively. However, the life expectancies of the population in the year of their respective competitions were 60.5 and 60.2 years, which shows that SP and EM athletes live 8.38±2.16 years and 8.82±1.67 respectively longer than their compatriots, as shown in Figure 4.

Discussion

This study is the first to investigate longevity among Brazilian athletes. The results suggest that Brazilian Olympic athletes live nearly 8 years longer than the expected lifespan for the age matched general population. Additionally, in our sample, the longevity of SP athletes was not significantly different to that of EM athletes, which differs from previous reports in studies from developed countries.

Our findings confirm previous reports that elite athletes live longer than the general population[5,10-13,15]. Specifically, two previous studies[5,8] provide strong evidence of the greater longevity of Olympic athletes compared to the general population. Clarke *et al.*[5] examined 15,174 Olympic medalists from 9 developed countries and showed that athletes lived ~2.8 years longer than the general population. In a recent meta-analysis including nearly 165,000 former elite athletes of both sexes from different sport types, Runacres *et al.*[8] confirmed the current knowledge, while refuting the 'J' shaped hypothesis for vigorous exercise and mortality by showing greater longevity for the athletes when compared to the general population.

To achieve Olympic status, an athlete invests in many years of physical training, thus it is expected that some physiological mechanisms associated with cardiovascular, neuromuscular, and immune systems triggered by systematic vigorous physical exercise can influence physical and psychological health and, consequently, increase longevity by decelerating the aging process[16]. For instance, maximum oxygen consumption (VO2max) during adulthood has previously been associated with lower mortality rates. This association may be explained by the higher starting point of individuals with higher VO2max values at younger ages, which may lead to greater health and functional capacity when they become older[16].

Unfortunately, we were not able to record the cause of death of most of the athletes in the current sample. The reduction in mortality from chronic non-communicable diseases may be the main explanatory factor for the greater longevity of Olympians observed in our study, in accordance with recent findings from 8,124 US athletes[17]. Antero *et al.*[17] showed that the longevity advantage for US athletes compared to the general population was primarily attributed to the lower risk of death from cardiovascular diseases followed by cancer, respiratory diseases, external causes, endocrine and metabolic diseases, and digestive system diseases. However, mortality rates due to nervous system disorders and mental illnesses were not different from the general population[17].

When we consider the epidemiological transition that Brazil experienced in the middle of the 20th century, with important changes in the mortality profile, moving from infectious diseases to non-communicable diseases as the main causes of death[18], we can suggest that the deaths in our sample were mainly due to non-communicable diseases and senility, as most Olympians died after 1970.

It is noteworthy that the positive effects of vigorous systematic exercise are reversible after a period of detraining, depending on physiological adaptations, with different rates of decline[19]. In this regard, little is known about the potential "legacy" effect of systematic vigorous exercise

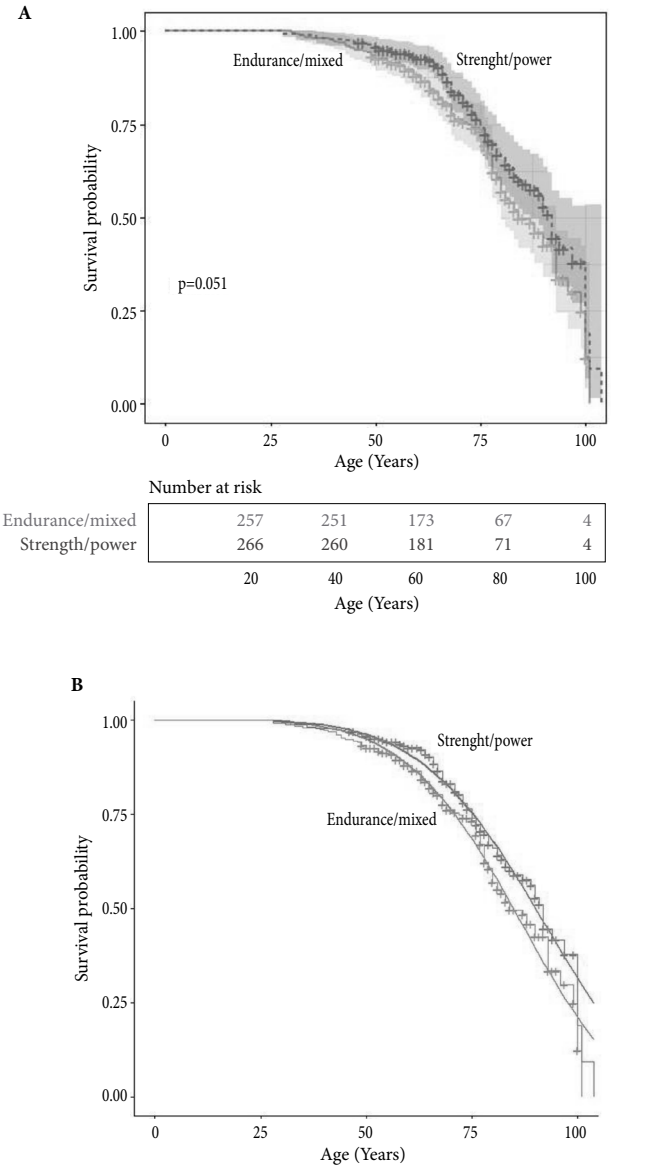

Figure 3. (A) Kaplan-Meier. (B) Weibull survival models of probability with 95%CI (shaded areas) for former Brazilian Olympians split by sport types.

Source: Authors.

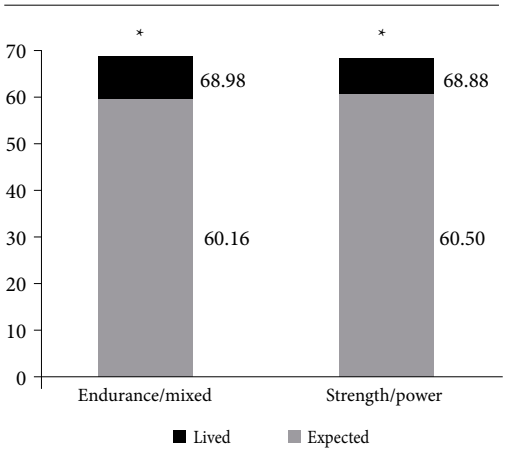

Figure 4. Differences between life expectancy of the age matched population (gray) and athletes' lifespan (black). *p<0.05.

Source: Authors.

during young adulthood on the morbidity and mortality of athletes after retirement. The majority of studies with longevity as the outcome did not assess lifestyle habits after the end of the athletic career[5,9,20], thus, the question on how much exercise and its characteristics before retirement influence athletes' longevity remains largely unknown, as part of this outcome may be due to positive behavioral facets of lifestyle after retirement.

It has been reported that former athletes who later adopt a sedentary lifestyle present an increased risk of developing chronic diseases, such as diabetes and cardiovascular disease[21]. On the other hand, former athletes with a physically active lifestyle after retirement have better body composition and a lower risk for cardiovascular disease, metabolic syndrome, and non-alcoholic fatty liver disease[22]. These findings highlight the impact of an athlete's post-retirement lifestyle on morbidity and mortality. However, longevity also has other environmental (e.g., access to health services, nutrition, socioeconomic characteristics and wealth) and genetic[5] components. Socioeconomic status – measured as a combination of education, income, and occupation – is a well-known factor that may influence human longevity. For former athletes with a higher income for example, medical care and technology accessibility, healthier nutrition, and physical activity facilities are probably more easily available[7]. Higher socioeconomic status could also expose athletes to a lower risk of violence and homicide[17]. Despite these "potential" but speculative relationships between socioeconomic status and longevity in athletes, mortality remains lower in athletes compared to controls, even after accounting for socioeconomic status[23], highlighting the influence of other factors in longevity. We cannot exclude the hypothesis that our athletes are part of a select group of individuals genetically predisposed to live longer. However, this hypothesis has not been confirmed[24]. Meanwhile, different to our hypothesis, the expected negative effect of being a citizen of a developing country on the aforementioned environmental factors does not seem to play a role.

Interestingly, there was no statistically significant difference in longevity between the SP and EM groups, which is a different outcome from previous studies[5,7-9,25,26]. The literature more frequently shows greater longevity for endurance athletes (e.g., marathon runners, cyclists), with gains of 4 to 8 years of lifespan when compared to the general population[5,8,22,27]. However, other previous evidence[17], does not confirm differences between sport types, except for some specific sports (i.e., fencing, shooting) which present a similar risk of death to the general population.

Some explanations for the greater survival of EM athletes have been previously suggested, including more vigorous physical activity levels[22,28] a higher proportion of slow-twitch fibers conferring metabolic and cardiovascular protection[9,22] and higher aerobic fitness associated with a lower risk of several cardiovascular, inflammatory, and pulmonary diseases and some types of cancer[7,9].

Meanwhile, SP athletes tend to have a higher body mass and body mass index (BMI), both factors independently associated with mortality[7,25]. Furthermore, the use of anabolic steroids is more frequent in SP athletes making them more vulnerable to mental disorders, suicide[29], and cardiovascular and liver diseases[30]. Thus, it could be speculated that, in our sample, some of these factors did not exert their influence.

Alternatively, it is possible that the low number of athletes and the limited statistical power of our study did not allow other comparisons between SP and EM[8]. Moreover, the differences between studies for sport type classification also deserve consideration. For example, the study by Kujala *et al.*[22] assigned endurance runners and cross country skiers to the "endurance" athlete group; sprinters, weightlifters, and track and field throwers were assigned to the "power/speed" group; while a third group named "other" comprised soccer, ice hockey, basketball players, boxers, wrestlers, and other track and field subdisciplines. Meanwhile, in our study,

we grouped endurance and team sport athletes into the EM group, thus including athletes from different sports with diverse aerobic fitness levels. This is an important aspect that should be considered when comparing studies on this topic. We decided to create only two groups with apparently different metabolic demands because of the reduced sample available for comparisons. Of note, we initially assigned volleyball athletes to the EM and later to the SP group because of the reduced levels of intense activity during matches. The non-significant difference between groups was maintained in both analyses, thus confirming the consistency of our criteria.

Interestingly, the study by Lee-Heidenreich *et al.*[25] including the top 20 former male and female Olympic high jumpers, discus throwers, and marathon and 100-m runners showed that life-expectancy of high-jumpers and marathon runners was longer than that of throwers and sprinters, which may be explained by the lower body mass of the first group. These findings suggest that differences in athletes' longevity may be attributed to factors (e.g., body mass) other than the metabolic profile of the sport. Further studies should verify the relative effect of different facets of physical fitness, including aerobic fitness and body composition.

This is the first study to assess the longevity of Brazilian Olympic athletes. However, some limitations should be highlighted: (1) We were unable to find information about the date of birth of some athletes, and thus, 165 athletes were excluded from our sample, which may have implied less statistical power. However, most previous studies have exhibited similar limitations[5,17] although in our study these 165 would represent 23.98% of the total sample. (2) Since socioeconomic characteristics of most Brazilian athletes were not available, we did not control our analysis for these factors. However, as we believe Brazilian Olympians have a similar ethnic and social profile to the general population, we can disregard this potential influence. In contrast, this may represent an important difference with other studies with diverse socioeconomic characteristics of samples from developed countries. (3) Given the low representation of female athletes in this study when compared to previous studies[6,8], the analyses were not performed by sex. Assuming that male and female elite athletes share common determinants for greater longevity[17], this may not represent a limitation.

Conclusion

Brazilian Olympic athletes live about 8 years longer than expected for the general population matched for sex and age. However, there are no differences in longevity between athletes in strength and power sports when compared to those in endurance and mixed sports.

Collaborations

The authors made substantial contribution to the submitted manuscript by working on the conception and design, analysis and interpretation of the data and revising it critically for intellectual content.

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