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MORTALITY OF ELITE FOOTBALL PLAYERS IN PORTUGAL AND SPAIN

MORTALIDAD DE FUTBOLISTAS DE ÉLITE EN ESPAÑA Y PORTUGAL

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Abstract

The health benefits of physical activity have been demonstrated. However, there is a growing debate over the potential adverse effects of strenuous physical activity, particularly at a professional level. The goal of this work is to investigate whether elite athletes live longer than general populations, by a comprehensive survival analysis of two populations of professional football players.

Lifespan data of Portuguese and Spanish football players, who have represented the national teams, were collected. The mortality of each cohort is then compared to that of the respective standard population, using data available in the *Human Mortality Database* and four different approaches. At the end, a comparison between the mortality of Portuguese and Spanish football players is also carried out.

Keywords: elite football players, mortality measures, Portugal, Spain.

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Resumen

Los beneficios para la salud derivados del ejercicio regular están científicamente probados. Sin embargo, cuando se trata de deportistas profesionales, cuya actividad física es muy intensa, los beneficios ya no son una evidencia clara. El objetivo de este trabajo es investigar si los deportistas de élite viven más tiempo que la población general. Se recogieron datos sobre la fecha de nacimiento y muerte (en su caso) de los jugadores portugueses y españoles que representaron su selección, así como otras variables de interés. Cada grupo de jugadores se compara con la población general del país respectivo, utilizando los datos disponibles en la *Human Mortality Database* y cuatro enfoques diferentes. Al final, también se compara la mortalidad de futbolistas portugueses y españoles.

Palabras clave: futbolistas de élite, medidas de mortalidad, España, Portugal.

1. Introduction

Regular physical exercise is beneficial, contributing to the prevention of cardiovascular diseases, hypertension, obesity, depression and some types of cancer (Hurley & Reuter, 2011). The World Health Organization (WHO, 2010) recommends children should spend at least 60 minutes of moderate to vigorous-intensity physical activity daily, and adults are advised to spend at least 150 minutes per week. Using a cohort of men who have enrolled as undergraduates in Harvard University in 1916-1950 (Lee & Paffenbarger, 2000) show that greater energy expenditure is associated with lower mortality, more pronounced for vigorous than moderate activities.

However, recent controversy exists regarding the potential adverse effects of repeated exposure to high levels of physical exercise, such as those required by professional sports. One of the topics of current debate is the increased susceptibility of elite athletes to cardiovascular diseases. High-competitive sports may lead to physiological changes in the heart, usually known as "athlete's heart".

It has been hypothesized that prolonged aerobic exercise is more prone to lead to these changes. Groups of ultra-endurance athletes have often been assessed to study this relationship but results are somewhat conflicting. Some conclude that ultra-endurance exercise elevates oxidative stress, leading to the development of acute cardiac dysfunction that increases the risk of cardiovascular diseases and mortality (Knez, Coombes, & Jenkins, 2006; Laslett, Eisenbud, & Lind, 1996; La Gerche et al. (2012)). Other do not find measurable persistent abnormalities of cardiac function, suggesting that the response to oxidative stress might be mitigated by exercise-induced adaptations, such as increased antioxidant defense and less reactive oxygen species production (La Gerche, Boyle, Wilson & Prior, 2004).

In a comprehensive study assessing world-class endurance athletes (Pelliccia et al., 2010) concluded that uninterrupted training/competition over long periods of time (for more than eight years on average) was not associated with symptoms of cardiomyopathies.

The debate on the consequences of heart remodeling in elite athletes and the safety of long-term and intense sports participation is fueled by news media reports of sudden cardiac deaths. Also the high frequency of injuries has brought some sports under scrutiny, especially those with a high risk of bodily collision and physical contact, with a history of repetitive brain injuries, including symptomatic concussions (Koning, Matheson, Nathan & Pantano, 2014; McKee et al., 2009; Zwiers et al., 2012). This leads to early onset dementia and it is associated with reduced life expectancy.

2. Literature review

A number of studies have attempted to study the risk-benefit ratio of intensive exercise by assessing mortality in elite athletes. The main findings vary according to nationality and sport practiced. In addition, the methods employed, the period of enrollment in sports and the follow-up time cause large variations in the results, a reason for them not to be easily transposable from one population to another.

Sanchis-Gomar, Olaso-Gonzalez, Corella, Gomez-Cabrera & Vina (2011); Marijon et al. (2013) analysed cyclists participating in the Tour de France, one population of particular interest, since Tour de France is one of the most demanding and difficult sports event in the world. Sanchis-Gomar et al. (2011) analysed participants from France, Italy and Belgium between 1930 and 1964. They computed the percentage of survivors for each age and compared the rates with those of the pooled populations of the three countries, for the appropriate birth cohorts. Using a polynomial regression curve of second order (Ribeiro, 2014; Wooldridge, 2012) and a non-parametric Mann-Whitney U test (Mann & Whitney, 1947), the authors found that longevity of the cyclists is significantly higher. Also Marijon et al. (2013), who analysed French cyclists participating at least once in the competition from 1947 to 2012, confirmed the reduced mortality, using standardized mortality ratios and their 95% confidence intervals, by age-groups, calendar periods and specific causes of death.

Lin, Gajewski and Poznanska (2016) applied a parametric frailty survival model to a group of Polish athletes who have participated in the Olympic Games from 1924 to 2010. Results suggest that these athletes exhibit lower risk of mortality than the general population. Sarna, Sahi, Koskenvuo & Kaprio (1993) estimated that Finnish long-distance runners and cross-country skiers, competing internationally between 1920 and 1965, live 5.7 years longer than age and area of residence-matched reference male cohorts in Finland.

Regarding team sports athletes, for example, baseball players (Abel & Kruger, 2005; Kalist & Peng, 2007) and National Football League (NFL) players (Koning et al., 2014) show lower mortality rates than those of the general population.

Possible explanations for the mortality improvement: high physical fitness levels; the fact that excellence in sport is attained only by the healthiest and the fittest; better access to quality health care; elite athletes tend to maintain healthy habits after retiring.

A few studies however do not find a survival advantage in elite athletes. For example, Italian soccer players active in the three top leagues, between 1960 and 1996, do not show a mortality different from that of the Italian population (Belli & Vanacore, 2005). Likewise, New Zealand rugby players had the same life expectancy as the general population (Beaglehole & Stewart, 1983). Furthermore, there is a report by Pärssinen, Kujala, Vartiainen, Sarna & Seppälä (2000) observing that 12.9% of Finnish powerlifters died prematurely (average age of death of 43 years) compared to 3.1% of the general population during a 12-year follow-up period. Use of steroids to enhance performance and higher prevalence of obesity and diabetes later in life are the reasons. In other cases, an excess mortality by specific causes of death is observed, see Belli and Vanacore (2005), Taioli (2007) and Lehman, Hein, Baron & Gersic (2012).

A different approach is that of Zwiers et al. (2012), who do not compare athletes to the general population. They compare Olympic athletes practicing sports with different levels of physical intensity and contact. The study assesses the mortality risk of athletes who participated in the Olympic Games between 1896 and 1936 in 43 different disciplines. Using a left truncated Cox Proportional Hazards model (Cox, 1972), the authors calculate hazard ratios for all-cause mortality. Results show that athletes engaging in disciplines with increasing cardiovascular intensity are not associated with a higher mortality risk. A separate analysis of the static and dynamic components shows similar non-significant results. But the study points to a higher mortality of athletes practicing sports with a high risk of bodily collision and high physical contact.

Other works show that mortality results vary even for athletes practicing the same sport. For instance, (Koning et al., 2014) studied NFL players from two different seasons, 1970 e 1994. Players were divided in subgroups, by race, position played (line, skill and other) and number of games during career.

A Cox Proportional Hazard Model was developed to examine if the observable risk factors influence mortality within the population of players. There is evidence that line players have higher mortality than other players, which is expected since they are more susceptible to cardiovascular diseases due to the higher body mass index (BMI). In the 1970 cohort, white players exhibit a 33% lower hazard rate than non-white players, but this difference does not persist for the 1994 cohort. An interesting finding is that players who play more than two seasons face higher mortality rates than other players. In another study using a different cohort of NFL players, Baron, Hein, Lehman and Gersic (2012) evaluated the association of position category and BMI with cardiovascular disease mortality. Among other results, the authors found that mortality due to cardio vascular diseases was superior for players with larger BMI and for defensive linemen, compared to offensive linemen.

3. Methodology

In our analysis, there is a special focus on comparing the mortality of the population under study (a cohort of elite athletes) with a standard population (reference population). Four complementary approaches based on methods found in the literature will be followed.

We will use first the computation of summary mortality indices, see IFOA (2011) and Breslow and Day (1987). In the context of compa ring the mortality results of different populations, a problem arises if they have different structures with respect to background characteristics. In this case, rates and ratios must be adjusted to ensure the comparability between the heterogeneous populations, a process known as standardization, which has been used in actuarial applications since the mid-18th century (Keiding, 1987). Mortality rates are commonly standardized by age, sex, race, and calendar period. Factors such as occupation, nutrition, housing, education and genetics, also contribute to differences in mortality, but extensive data may be required so these adjustments are less frequent.

Each population is decomposed in groups (strata), having certain characteristics in common. We start by calculating the central exposed to risk for an individual in a given group. Individuals are followed-up in the group, from entry until exit. The computation of exposed to risk is crucial to calculate the mortality measures that will be used, namely the crude mortality rate (CMR), the directly and indirectly standardised mortality rates (DSMR and ISMR) and the standardised Mortality Ratio (SMR).

Second, it is useful to compare two (or more) populations based on survival functions. In this paper, the purpose is to provide a comparison between the survival of the population of elite athletes (observed) and that of the standard population (expected). The Kaplan-Meier estimator of the observed survival function (Klugman, Panjer & Willmot, 2008) is one of the most used methods for statistical comparison and graphic display of survivorship over time. The most common approaches to the expected survival function are the exact method, the cohort method and the conditional expected survival. These three methods differ in how long the athlete's counterpart in the standard population is considered to be at risk for the calculation of the expected survival. The exact method, known as Ederer I method (Ederer, Axtell & Cutler, 1961), assumes a complete follow-up for all athletes; consequently, the matched individuals are considered to be at risk indefinitely. The conditional expected survival, known as Ederer II method (Ederer & Heise, 1959), is based on the actual follow-up time, therefore, matched individuals are considered to be at risk only until the corresponding athletes die or are censored. The cohort method (Hakulinen, 1982), takes into account potential follow-up time, which is the maximum possible time that an individual can be followed-up from the date of entry into study to the last potential time of observation. Explicitly, if the study subject is censored, the matched referent is assumed to be no longer at risk (actual follow-up), but if he/she dies, the counterpart is considered to remain at risk (maximum potential follow-up).

A survey of the three methods is in (Pokhrel, 2007; Therneau & Offord, 1999).

To deepen the analysis, providing a time dimension measure for athletes' longevity, we also studied the number of years of life lost (YLL) in case of shorter longevity than the standard population, or saved (YLS), otherwise. We used the method proposed by Andersen (2013), developed to studies with cancer patients, to calculate the expected number of years of life lost (saved) due to a given cause of death before a certain age. In sports, the overall years lost/saved is obtained as a stand-alone measure of mortality, but it can be determined for each major cause of death, as well as according to the main type of physiological effort, allowing comparisons between groups (Antero-Jacquemin, Pohar-Perme, Rey, Toussaint & Latouche, 2018).

The fourth insight was to search if there are mortality differences inside the group of athletes, resulting from having different characteristics. For example, it can be investigated if mortality of a team player (football, baseball, etc.) is influenced by his/her position in the field. Cox Proportion Hazard Model (Cox, 1972) is applicable in this context, besides being one of the most widely used tools of survival analysis.

4. Applications

It was possible to collect data from two populations of professional football players, who have represented at least once their National Team, namely, the players of the Portuguese Football Team and the players of the Spanish Football Team. Mortality of players was compared with that of the population of their respective countries, using the *Human Mortality Database* (HMD, http://www.mortality.org/).

For all data in this collection and throughout the study, age and time are arranged in 1, 5, and 10-year intervals. In the computations, available death rates, exposure-to-risk and life tables are used in the six configurations available in the HMD: 1x1, 1x5, 1x10, 5x1, 5x5, and 5x10, with the first number always referring to the age interval and the second number to the time interval. For example, 1x5 denotes a configuration with single years of age and 5-year time intervals. Furthermore, the intervals are inclusive, both for age and time, in the sense that the age-group 20-24 extends from exact age 20 up to, but not including, exact age 25, as well as the time period designated by 1970-1974 begins on 1 January 1970 and ends on 31 December

1974. Following the convention in the HMD, the first year of life (age 0) is always separated from the rest of its age group (ages 1-4), and the last age category is for ages 110 and above.

In HMD, data is available in periods – period data, i.e., by year of occurrence – and in cohorts – cohort data, i.e., by year of birth. Statistics are collected, published and tabulated in period life tables. Moreover, in the standardization process, the central mortality rates (m_j), which are referred as death rates in HMD, are widely used. For period life tables, the values of m_j below age 80 are by definition equal to the observed death rates. At older ages, the number of deaths and the exposure-to-risk eventually become quite small, leading to considerable random variation in observed death rates. In order to obtain an improved representation of the underlying mortality, death rates for ages greater than or equal to 80 are smoothed by fitting a logistic function, before being converted to probabilities of death in HMD. For cohort data, this adjustment is not performed.

Regarding statistical analysis, p-values lower than 0.05 were considered to indicate statistical significance and the 95% confidence intervals were calculated using the exact method (Liddell, 1984). All data was analyzed using R software (version 3.4.4).

4.1 Mortality of Portuguese Football Players

4.1.1 Data collection and statistical analysis

Data on Portuguese football players who have represented the national team, for the 1921-2018 period, was collected from the official website of the Football Portuguese Federation (http://www.fpf.pt), from a very complete Portuguese website with worldwide statistics of football (http://www.zerozero.pt/) and complemented with other sources (https://eu-football.info/, http://www.national-football-teams.com/). The most difficult information to obtain was the date of death, which sometimes was found by a deep search in the football team's websites, sports news and memorials.

A total of 608 Portuguese football players have represented at least once the national team in either World Cups, European Championships or even friendly games; 59 football players were excluded, due to unknown date of birth, date of death, or both. Among the remaining 549 footballers, 139 have died by 31 December 2018. The follow-up for each player was defined by the difference between the date of endpoint (31 December 2018 if alive; otherwise, the date of death) and the date of his first match representing the national team. The date of the end of the study was the only censoring point. Whenever the year of death was the only information, it was assumed that the player died at the middle of that year. The age of death ranged from 23 to 99 years old, with a mean of 68.44.

Information about the number of games played by the national team and the total number of games in their careers was collected. Players were also placed into one of four positional categories: goalkeeper, defender, midfielder and forward.

Table 1 lists summary statistics for the players followed during the 1921-2018 period, which corresponds to years of birth between 1894 and 1999. The overall mortality of players was compared with that of the Portuguese male population, using the *Human Mortality Database*. Notice that period life tables for Portugal are available from 1940 until 2018 and the national team's debut was in 1921, then, cohort life tables were used for the remaining period 1921-1939.

Table 1 - Characteristics of Portuguese football players (1921-2018 period). Sources: FPF; Zerozero.pt; national-football-teams and eu-football.info

Total number of players	549
Alive at 31 December 2018	410 (75%)
Dead at 31 December 2018	139 (25%)
Age at the first representation (mean±SD)	23.85 (± 3.10)
Age at the end of the study, for the players still alive (mean±SD)	54.03 (± 17.85)
Age at death (mean±SD)	68.44 (± 15.44)
Number of games played by the national team (mean±SD)	14.61 (± 20.51)
Number of games played in the entire football career (mean±SD)	303.53 (± 149.54)
Goalkeepers	49
Defenders	169
Midfielders	175
Forwards	156

4.1.2 Results

As a first approach, overall mortality of the Portuguese football players was compared with the Portuguese male population through the computation of standardised mortality ratios, along with 95% confidence intervals by the exact method.

The computations were performed with the data standardised in the six different settings of age and time-intervals defined before. The results showed to be very similar; for instance, the SMR ranged from 0.6219 in a 5x10 setting to 0.6451 in a 1x5 setting. To maintain a uniform format, from now onwards, the interpretations will be based on the results reached with a 5x1 configuration, that is, 5-year age classes and 1-year intervals.

An overall standardised mortality ratio of 0.6239 suggests a substantially and significantly lower mortality of Portuguese football players compared with the general Portuguese male population ($p < 0.05$). The corresponding 95% confidence interval is [0.5222; 0.7391], that is, if the study was repeated many times using samples from the same population, the true SMR would be expected to fall within that interval in 95% of the times (Klugman, Panjer & Willmot, 2008).

Overall mortality according to the players' positions was observed to be lower than that of the general population for all four categories (SMR<1), although marginally not significant in the case of midfielders ($p = 0.0532$), et Table 2.

Table 2 - SMR for Portuguese players, 95% CI and p-value: overall and stratified by position

	SMR	95% CI for SMR	p-value
Overall	0.6239	0.5222 – 0.7391	0.0000
Goalkeepers	0.5582	0.3124 – 0.9206	0.0188
Defenders	0.5698	0.3923 – 0.7999	0.0005
Midfielders	0.7187	0.4977 – 1.0041	0.0532
Forwards	0.6287	0.4681 – 0.8265	0.0004

Categorizing deaths in 10-year age classes, SMR obtained are all lower than one, which reveals consistency across age (figure 1). For instance, the SMR for the 60-69 age class is 0.6038 (95% CI: 0.3869 – 0.8983; $p = 0.01$), meaning that it was observed an actual number of deaths 39.62% lower than the expected. However, the SMR of the 50-59 and 70-79 age classes are non-significant ($p > 0.05$).

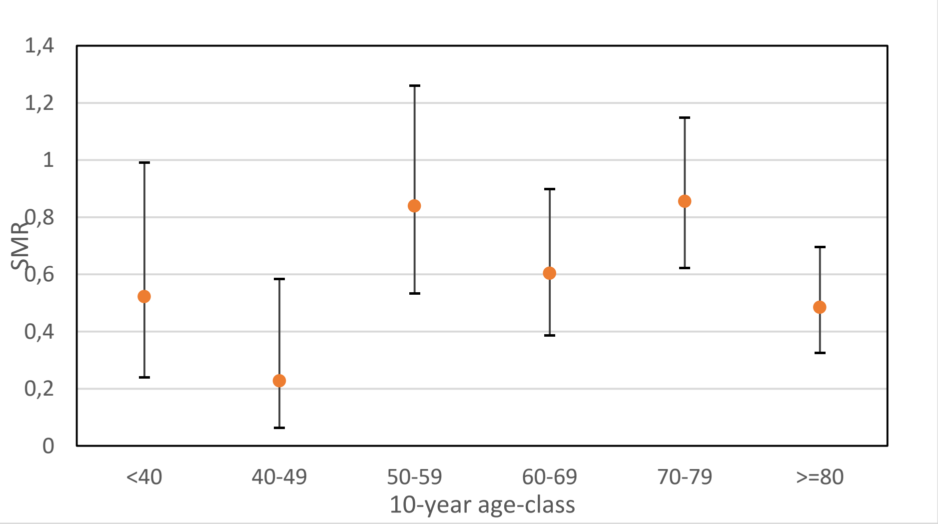

Figure 1 - SMR for Portuguese players by 10-year age class and respective 95% CI

The period effect was evaluated using two complementary approaches. First, deaths that occurred within each of the calendar periods 1921-1952, 1953-1973, 1974-1994, 1995-2018, were considered and the respective SMR and 95% CI estimated (table 3). A lower mortality of players, when compared with the general male population, was observed across the periods, except the first one, 1921 – 1952 (a non-significant SMR of 1.29). Among the nine deceased players in this period, three causes of death are known, including septicemia, food poisoning and complications following an eyes disorder.

Table 3 - Standardized mortality ratio over time (four periods) for Portuguese players

Period	Actual deaths	Expected deaths	SMR	95% CI	p-value
1921-1952	9	6.97	1.29	0.59 – 2.45	0.53
1953-1973	13	22.19	0.59	0.31 – 1.00	0.05
1974-1994	49	64.34	0.76	0.56 – 1.01	0.06
1995-2018	68	128.30	0.53	0.41 – 0.67	0.00

In the second method to account for mortality trends over time, the same calendar periods were considered, with the difference being the allocation of the players according to the date of the first match played in the national team. Among the players who have represented Portugal for the first time between 1921 and 1952, 89 have already died by 31 December 2018. In this scenario, the standardization process estimates that 124.53 individuals die until the end of the investigation, yielding a SMR of 0.7066 (0.5667-0.8706). Of the 121 and 163 footballers who played for the first time in the 1953–1973 and 1974–1994 periods, respectively, 42 and 8 had died by 31 December 2018, yielding SMRs of 0.5641 (0.3992-0.7741) and 0.3588 (0.1443-0.7393). All estimated SMR were statistically significant ($p<0.05$). Since only the youngest are considered in the last period, 1995-2018, no death was recorded in this group.

For simplicity, in the estimation of Kaplan-Meier observed survival function of Portuguese football players, follow-up was defined as: age at exit from study - age at entry into study. The estimation of expected survival was performed using the three cited methods, considering 1-year intervals. Hakulinen and Ederer II curves are very similar, and the last one was chosen to be illustrated in Figure 2, along with the observed survival curve.

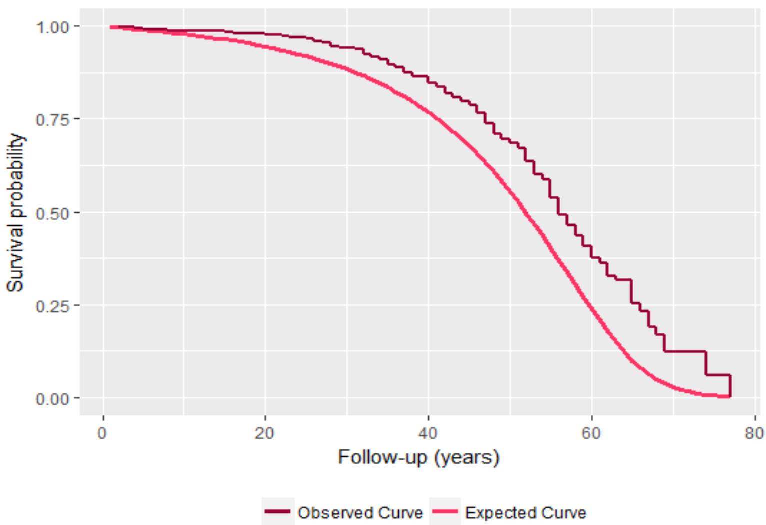

Figure 2 - Portuguese players observed and expected survival curves

The observed curve is generally above the expected curve, shifting to the right early in the follow-up period and widening the gap until the end of follow-up. The difference between the curves is statistically significant. This strengthens the conclusion of greater survival of Portuguese football players when compared to the standard population.

Besides, observed and expected survival probability are also estimated considering age in x-axis, instead of follow-up time. Following Andersen (2013), the determination of life years saved/lost is based on the lifetime distribution function $F_x(t) = {}_tq_x = 1 - S_x(t)$, which represents the probability that a life aged x dies before attaining age $x + t$. The area below the observed distribution function (at each age) estimates the average number of life years lost from the time of first representation of National Team until the age of 99. Likewise, the average number of years lost by the counterparts of the athletes in the general population is calculated by the area under the expected distribution function. Then, the lower risk of death of the Portuguese football players is estimated by the difference between the two areas.

Graphically, it is the area between the two curves in figure 2. Numerically, the players cohort saved on average 5.73 years of life in relation to the general population, until the final age point of 99 years-old.

Notice that the result would be the same using survival distributions – the number of years saved would continue to be estimated by the area between the two curves. In this case, the area under each curve would be interpreted as the temporary life expectancy.

Cox Proportional Hazard Models were used to evaluate the association between player position on the field, and total number of games, with overall mortality. Several models were developed using different time scales and adjustment for confounders (age at first match, year of birth and/or period of participation). Results in this section were obtained considering age as the time scale, with players entering the analysis at the age of first representation of the national team (left-truncation) and exiting at their death/censoring age. Consequently, every model was adjusted for age.

In table 4 results are summarized for number of games in the entire career, which are treated as a categorical variable after application of decision trees. Model G.1 is only adjusted for age, while model G.2 is additionally adjusted for calendar period of participation (allocation by year of first representation). The category of number of games ≤134 and the calendar period 1921–1952 were chosen to be kept in the baseline, since are convenient levels for interpretation of results, besides having a higher observed death rate.

Table 4 - Cox proportional hazard ratios and 95% CI for number of games (model G.1 – adjusted for age; model G.2 – adjusted for age and period of participation) for Portuguese players

	Hazard Ratio (95% CI)	
	Model G.1	Model G.2
N. Games]134,366]	0.53 (0.36 – 0.78)	0.63 (0.42 – 0.92)
N. Games > 366	0.82 (0.47 – 1.43)	1.34 (0.74 – 2.44)
PP 1953-1973		0.49 (0.32 – 0.75)
PP 1974-2018		0.22 (0.09 – 0.53)

Table 5 displays the results for player position, with Model P.1 being adjusted for age and Model P.2 being adjusted for age and calendar period of participation. Likewise, 1921–1952 period is kept in the baseline, as well as forwards, which were chosen as the reference group due to the higher observed death rate.

Table 5 - Cox proportional hazard ratios and 95% CI for position in the field (model P.1 – adjusted for age; model P.2 – adjusted for age and period of participation) for Portuguese players

	Hazard Ratio (95% CI)	
	Model P.1	Model P.2
Defenders	0.84 (0.54 - 1.31)	1.01 (0.64 – 1.58)
Goalkeepers	0.86 (0.48 - 1.53)	0.90 (0.51 – 1.61)
Midfielders	1.04 (0.67 - 1.61)	1.27 (0.81 – 1.98)
PP 1953-1973		0.50 (0.33 – 0.75)
PP 1974-2018		0.24 (0.10 – 0.55)

Table 6 includes multivariate models for number of games and player position analysed simultaneously.

Table 6 - Cox proportional hazard ratios and 95% CI for multivariate models including number of games and position in the field (model GP.1 – adjusted for age; model GP.2 – adjusted for age and period of participation) for Portuguese players

	Hazard Ratio (95% CI)	
	Model GP.1	Model GP.2
N. Games]134,366]	0.52 (0.35 – 0.77)	0.60 (0.41 – 0.89)
N. Games > 366	0.80 (0.45 – 1.42)	1.30 (0.71 – 2.37)
Defenders	0.90 (0.58 – 1.41)	1.03 (0.66 – 1.62)
Goalkeepers	0.93 (0.52 – 1.65)	0.92 (0.52 – 1.65)
Midfielders	1.16 (0.74 – 1.81)	1.37 (0.87 – 2.16)
PP 1953-1973		0.47 (0.31 – 0.72)
PP 1974-2018		0.21 (0.09 – 0.51)

From all the models it can be concluded that position played is not a significant predictor of mortality of Portuguese football players (CI for all models include the value 1).

Players in specific positions have different physical profiles and anthropometric characteristics. For example, the midfielders run the longest distances compared to forwards or defenders (Vigne, Gaudino, Rogowski, Alloatti & Hautier, 2010). Defenders have more body fat than forwards and midfielders. Forwards are the quickest players in the team. Goalkeepers tend to be the tallest and have a better performance on explosive power tests than players in the field (Sporis, Jukic, Ostojic & Milanovic, 2009). However, this work suggests that these distinct characteristics, besides others not mentioned, are not enough to lead to differences in mortality according to position for Portuguese football players. In fact, football players have similar training preparations regardless the position in the field.

Players with a total number of games between 135 and 366 exhibit decreased mortality when compared to players with less than 135 games (baseline), ranging from 37% lower mortality in the Cox model for number of games adjusted for age and period of participation (model G.2), to 48% lower mortality in the multivariate model having number of games and position as covariates and controlling for age (model GP.1). However, players with more than 366 games in their career do not verify a survival advantage in relation to players with less than 135 games. This result seems to indicate that a longer football career is beneficial for longevity up to a certain threshold.

4.2. Mortality of Spanish Football Players

4.2.1. Data collection and statistical analysis

Data on Spanish players in the national team for the 1920-2018 period was collected from the Spanish Association of International Football Players (http://www.aedfi.es/web/) and from a very complete website (http://www.bdfutbol.com/), being completed with other sources (https://eu-football.info/, http://www.national-football-teams.com/). The procedures applied were the same as for the Portuguese players, with a few modifications, mentioned when required.

From the 785 football players who have represented at least once the Spanish team, only 7 were excluded due to unknown date of death. Of the remaining 778 footballers, 297 died before 31 December 2018. The summary statistics for the players followed from 1920 to 2018, corresponding to years of birth between 1889 and 1997, are in table 7.

Table 7 - Characteristics of Spanish football players (1920-2018 period). Sources: AEDFI; Bdfutbol; national-football-teams and eu-football.info

Total number of players	778
Alive at 31 December 2018	481 (62%)
Dead at 31 December 2018	297 (38%)
Age at the first representation (mean±SD)	23.89 (± 2.84)
Age at the end of the study, for the players still alive (mean±SD)	53.44 (± 16.18)
Age at death (mean±SD)	70.01 (± 15.67)
Number of games played by the national team (mean±SD)	11.73 (± 19.74)
Number of games played in the football career (mean±SD)	282.02 (± 150.81)
Goalkeepers	53
Defenders	241
Midfielders	241
Forwards	243

Again, the overall mortality of Spanish players was compared with that of the Spanish male population, using the HMD. There was no need to use cohort data, since period life tables are available from 1908 onwards and the national team's debut was in 1920.

4.2.2. Results

In a similar way to the Portuguese case, mortality of the Spanish football players was compared with that of the Spanish male population through the computation of standardized mortality ratios, along with 95% confidence intervals. Computations were performed with the data standardised in the six different settings of age and time-intervals defined before. The results showed to be very similar, with SMR varying between 0.9395 in a 5x10 setting and 0.9483 in a 1x1 setting. Parallel to 4.1.2, interpretations will be based on the results obtained with a 5x1 configuration.

An overall SMR of 0.9412 was obtained for the Spanish football players, that is, it is estimated that this group of elite athletes have a 5.88% lower mortality than the Spanish standard population. However, the verified mortality difference based on SMR is not statistically significant at 5%, since the p-value is 0.3324. Indeed, the 95% confidence interval for SMR, [0.8334; 1.0595], contains the value 1. Therefore, the hypothesis of similar mortality of the Spanish football players with the general population is not rejected.

Regarding the position played, the SMR are lower than one, except for forward players. Again, the results are not statistically significant at 5%. Nevertheless, goalkeepers stand out with a p-value of 5.79%, meaning that, at 90% confidence level (α=10%), the SMR of 0.6481 would be significant, see table 8 - and figure 3, for the SMR by age-class.

Table 8 - SMR for Spanish players, 95% CI and p-value: overall and stratified by position

	SMR	95% CI for SMR	p-value
Overall	0.9412	0.8334 – 1.0595	0.3324
Goalkeepers	0.6481	0.3901 – 1.0122	0.0579
Defenders	0.9047	0.7130 – 1.1328	0.4188
Midfielders	0.9590	0.7735 – 1.1764	0.7415
Forwards	1.0607	0.8509 – 1.3074	0.6053

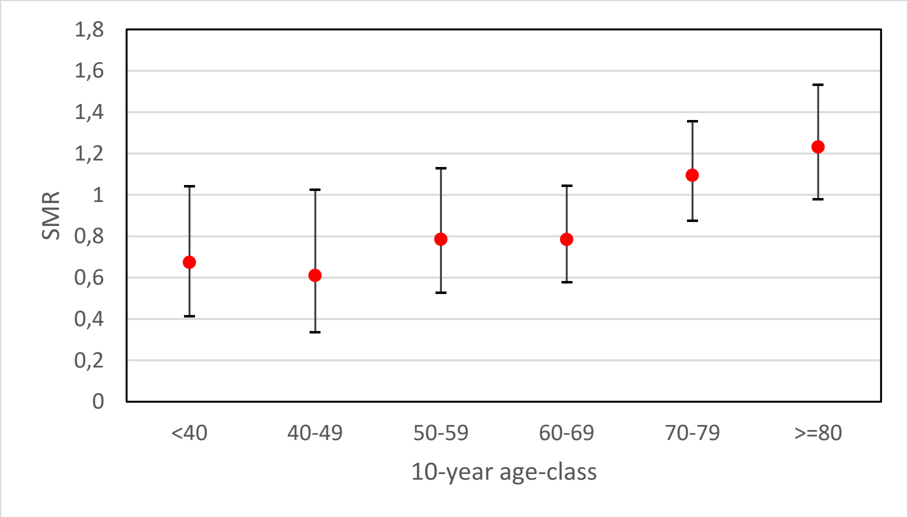

Figure 3 - SMR for Spanish players by 10-year age class and respective 95% CI

The SMR by age-class confirm that there is no statistical evidence of difference in mortality between players and its standard population (p-values > 0.05). Notice that values are lower than 1 for younger age-classes and greater than 1 for groups above 70 years-old. Again, some of these results would be significant at 90% confidence level. For instance, for the 40–49 age group SMR is 0.61, with a corresponding p-value of 6.35%.

Concerning the first approach for the period effect, deaths that occurred within each of the calendar periods 1920–1935, 1936–1955, 1956–1975, 1976–1995, 1996–2018 were considered and the respective SMR and 95% CI estimated (table 9).

Table 9 - Standardized mortality ratio over time (five periods) for Spanish players

Period	Actual deaths	Expected Deaths	SMR	95% CI	p-value
1920-1935	8	6.31	1.2674	0.5472 – 2.4972	0.6000
1936-1955	13	24.52	0.5302	0.2823 – 0.9066	0.0165
1956-1975	43	50.76	0.8472	0.6131 – 1.1412	0.3076
1976-1995	107	97.52	1.0973	0.8992 – 1.3259	0.3613
1996-2018	126	137.68	0.9152	0.7521 – 1.1153	0.4292

It was only in the 1936–1955 period that the SMR was statistically different from 1, being estimated a 46.98% lower mortality of Spanish players. This might be associated with the higher death rates of the Spanish general population as a consequence of the Civil War (1936–1939), a period of conflict and massive violence.

In the second approach to account for mortality trends over time, players were allocated to a period according to the date of their first representation of the Spanish National Team. The first three calendar periods were the same as in the first method, and the last two periods were joined, since only one death occurred among the players who first represented Spain between 1996 and 2018. Apart from the 1920–1935 period, all SMR were lower than 1; however, statistical evidence does not reject the hypothesis of identical mortality between the players and the Spanish general population for each period.

The observed Kaplan-Meier survival curve was estimated, considering follow-up in x-axis. The expected survival, based on the Spanish general male population death rates, was determined by Ederer II and Hakulinen methods, giving similar results. To keep consistency, the graph of Ederer II is illustrated, as well as the observed curve, in figure 4.

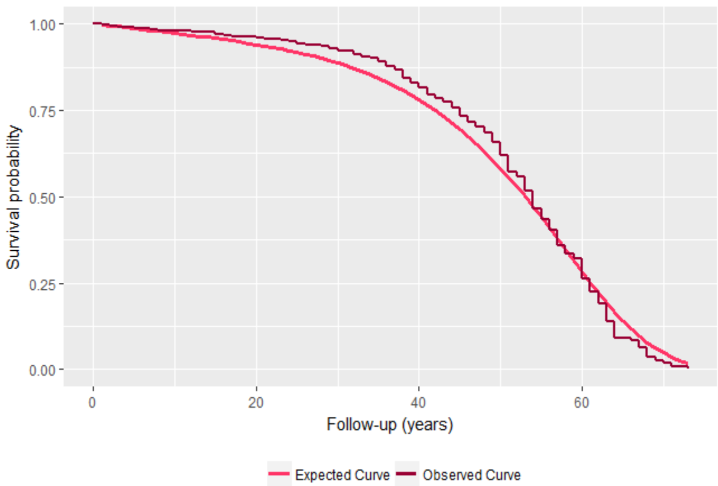

Figure 4 - Spanish football players observed and expected survival curves

In opposition to the Portuguese case, the observed survival curve does not lie entirely above the expected survival. It happens at the beginning, but as time increases, the gap between the curves progressively narrows, until $t = 54$, when the curves cross each other. The expected survival is superior at the end of the follow-up (from $t = 63$ onwards).

The years lost method is applied using the same approach as in the Portuguese case study, but since the observed and expected survival curves cross each other some ages will contribute to years saved, while others to years lost. At the end, Spanish football players saved on average 1.76 years of life in comparison to the Spanish general population, until 98 years-old.

Cox Proportional Hazard Models were again used to evaluate the association between player position on the field, and total number of games, with overall mortality, replicating what has been done for the Portuguese players. Table 10 shows the results for the number of games in the entire career, which was also transformed into a categorical variable through the application of decision trees. Model G.3 is only adjusted for age, while Model G.4 is additionally adjusted for year of birth. Players with less than 199 games were chosen as the reference group since they have the higher observed death rates.

Table 10 - Cox proportional hazard ratios and 95% CI for number of games (model G.3 – adjusted for age; model G.4 – adjusted for age and year of birth) for Spanish players

	Hazard Ratio (95% CI)	
	Model G.3	Model G.4
N. Games]198,350]	0.53 (0.40 – 0.7)	0.77 (0.54 – 1.07)
N. Games > 350	0.33 (0.2 – 0.53)	0.55 (0.30 – 0.95)
Birth Year		0.98 (0.96 – 0.99)

Regarding the position in the field, midfielders are kept in the baseline, also due to the higher observed death rate. Model P.3 is adjusted for age and Model P.4 is adjusted for age and year of birth (table 11).

Table 11 - Cox proportional hazard ratios and 95% CI for position in the field (model P.3 – adjusted for age; model P.4 – adjusted for age and year of birth) for Spanish players

	Hazard Ratio (95% CI)	
	Model P.3	Model P.4
Forwards	1.10 (0.81 – 1.47)	1.22 (0.91 – 1.64)
Defenders	0.88 (0.65 – 1.19)	1.02 (0.76 – 1.42)
Goalkeepers	0.58 (0.35 – 0.96)	0.65 (0.39 – 1.06)
Birth Year		0.96 (0.96 – 0.97)

Table 12 includes multivariate models for number of games and player position analysed simultaneously.

Table 12 - Cox proportional hazard ratios and 95% CI for multivariate models including number of games and position in the field (model GP.3 – adjusted for age; model GP.4 – adjusted for age and year of birth) for Spanish players

	Hazard Ratio (95% CI)	
	Model GP.3	Model GP.4
N. Games]198,350]	0.52 (0.4 – 0.68)	0.74 (0.52 – 1.04)
N. Games > 350	0.33 (0.19 – 0.54)	0.53 (0.31 – 0.94)
Forwards	1.28 (0.96 – 1.72)	1.28 (0.96 – 1.72)
Defenders	0.99 (0.73 – 1.34)	1.05 (0.77 – 1.43)
Goalkeepers	0.69 (0.42 – 1.14)	0.69 (0.42 – 1.14)
Birth Year		0.98 (0.97 – 0.99)

Results show that the number of games in the career of a Spanish football player influence their survival. Hazard ratios adjusted for age indicated a lower mortality for players with a greater number of games: 0.53 and 0.52 HR for players with number of games belonging to]198, 350] in, respectively, univariate (G.3) and bivariate (GP.3) models, when compared to the baseline; 0.33 HR for number of games > 350 in relation to the baseline group, both in univariate and bivariate models (G.3 and GP.3). These lower mortality risks remained after adjusting for year of birth, but with less pronounced hazard ratios, whereas the hazard ratio for players with number of games belonging to]198,350] became non-significant. The observed significant reduction of mortality for players with greater number of games in their curriculum underpins the findings of beneficial effects in longevity of sustained and strenuous competition.

Comparing forwards, defenders and goalkeepers with midfielders, there are no significant mortality differences. The exception was goalkeepers (6.8% of total players). This result is generally in line with the Portuguese study, reinforcing the idea that the position in the field is not a determinant factor for mortality of football players.

4.3. Comparing the mortality of Portuguese and Spanish Football Players

The previous computations of Portuguese and Spanish football players are based on different standard populations and some of the results are not comparable. To this end, a common standard population should be chosen to compare the mortality of the two populations under study, and then the DSMR and ISMR can be determined. In this case, the standardization process was done only by age (5-year age groups), providing a meaningful comparison of the age-specific mortality rates of each population.

First, it was used the Spanish general population (much larger) as the standard and, afterwards, the population of the Portuguese and Spanish football players were pooled to create a standard population. The relevant measures are illustrated in table 13.

Table 13 – Single figure measures of mortality (CMR, DSMR and ISMR) for Spanish and Portuguese football players based on two different standard populations.

	Standard Population	
	Spanish general population	Pooled population
CMR standard population	0.0111	0.0096
DSMR Portuguese cohort	0.0055	0.0080
DSMR Spanish cohort	0.0076	0.0108
ISMR Portuguese cohort	0.0065	0.0080
ISMR Spanish cohort	0.0088	0.0108

In both approaches, the DSMR as well as the ISMR are greater for the Spanish cohort of football players than for the Portuguese cohort. This required further clarification and motivated the comparison of the life expectancy at birth between the Spanish and Portuguese general populations, using available data in the HMD. For the 1940–2018 period, life expectancy at birth is higher for the Spanish population in relation to the Portuguese population for every year (apart from 1940 and 1941), as illustrated in figure 5.

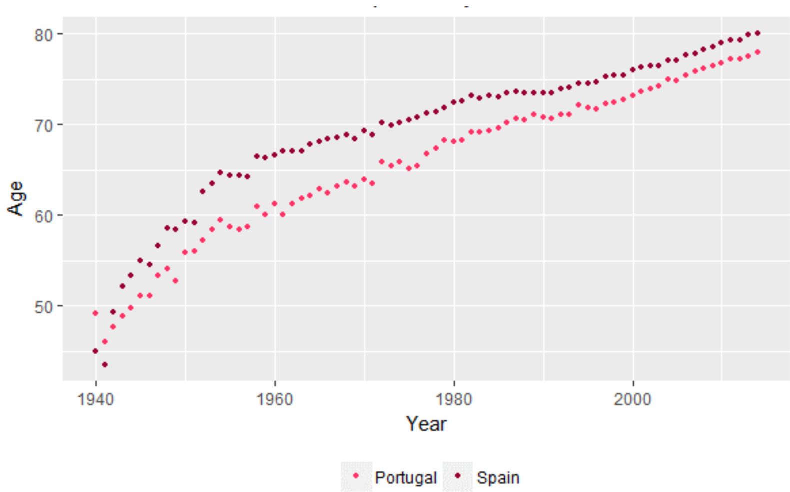

Figure 5 - Life expectancy at birth for Portuguese and Spanish populations (1940-2018).

Thus, the survival advantage of the Portuguese football players in comparison to the Spanish football players, combined with the lifespan advantage of the Spanish general population is a possible reason for the lower mortality of the Portuguese football players in comparison to its standard population. Nevertheless, further investigation is needed to justify the differences.

5. Conclusion

In the context of recent concerns regarding potential negative health effects of high-level physical exercise, research on the mortality of elite athletes is of particular interest. This study shows that playing football at an elite level does not increase overall mortality or shorten lifespan.

For Spanish players, it was not observed a mortality difference compared with the Spanish reference population. Results were more significant in the case of Portuguese players, with an average of 5.73 years of life saved and a 37.64% overall lower mortality when compared to the Portuguese population. This reduction in overall mortality was consistent across age-groups, time periods (except for deaths allocated to the 1921-1952 period) and position in the field. The difference between the observed and the expected survival curves since the beginning of follow-up illustrated the football players' survival advantage over the general population. The findings on Portuguese football players are in line with the study of Taioli (2007), who estimated 32% lower mortality for football players enrolled in the Italian A and B professional leagues between 1975 and 2003. Therefore, we can conclude that Portuguese elite football players live longer than the general population.

Regarding the position players occupy in the field, there is no major difference in mortality according to it, both for the Portuguese and Spanish cohorts, but it seems that an increasing number of games in the career generally contributes to lower mortality (these athletes are usually the fittest and also less frequently injured).

The cohorts of Portuguese and Spanish players were also compared through direct and indirect standardization methods, with a survival advantage for Portuguese athletes. Further research is needed to clarify the difference. For example, data on the causes of death would have been informative.

Although this essay tried to provide a complete mortality overview of the Portuguese and Spanish football players, it has limitations: it was not possible to validate the dates of death via official sources; players for whom the date of death is unknown, especially in the case of Portugal (accounting for 10% of the population under study) had to be excluded. However, these deaths correspond mainly (97%) to individuals whose first game representing the National Team occurred before 1953, and the SMR analysed separately for the periods of participation 1953-1973, 1974-1994 and 1995-2018 were significantly smaller than one, confirming the substantial reduction in overall mortality.

Analyzing mortality of football players from other countries could provide insight to the results obtained. Future research could also focus on assessing mortality of different sports, as well as including women elite athletes, since there is a current paucity of studies assessing their longevity. Again, available data is necessary to perform this investigation.

From a practical point of view, the contribution in this paper may be used by insurance companies and annuity providers to apply discounts, extra premiums or even to launch new products directed specifically to this segment. Although there may be legislation limiting underwriting factors for anti-discrimination purposes, the extra information would improve the fairness of the market with respect to this particular group of lives. Further studies would very likely allow extending the results to other sports.

As a final comment, following Sanchis-Gomar et al. (2011), "physicians, health professionals and general population should not hold the impression that strenuous exercise and/or high level aerobic competitive sports have deleterious effects, are bad for one's health, and shorten life". Such impression is strongly refuted in the large study conducted by Lee et al. (2012), where is proved that regular (moderate or higher level) physical activity can significantly increase life expectancy, irrespective of weight, age, sex and health condition. Hence, the final general recommendation should be to practice exercise regularly, ideally prescribed and supervised by a professional in the area – "Even a little is good; a lot is better if you are well trained" (Sanchis-Gomar et al., 2011).

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7. Databasis

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