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Article *in* Journal of Physical Education and Sport · September 2018

DOI: 10.7752/jpes.2018.s3210

Journal of Physical Education and Sport ® (JPES), 18(Supplement issue 3), Art 210, pp.1420 - 1426, 2018
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Mortality and economic expenses of cardiovascular diseases caused by physical inactivity in Spain

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Published online: August 31, 2018
(Accepted for publication July 15, 2018)
DOI:10.7752/jpes.2018.s3210

Abstract:
Non-communicable diseases caused 16 million early deaths in 2016 according to the data published by the World Heatlh Organization. Insufficient physical activity has become an international concern since several years ago and it is strongly related to these early deaths. The present study estimated the mortality and economic expenses of cardiovascular diseases caused by physical inactivity in Spain. Mortality attributable to physical inactivity (MA) was evaluated as the product between the population attributable fraction (PAF) and the number of deaths caused by associated cardiovascular diseases. The statistical value of life (SVL) was determined, following the human capital approach, from which SVL was estimated through the productivity lost by early death. The economic expenses were calculated using MA and SVL, classifying by gender, age group and level of physical activity. A sensitivity analysis was carried out to evaluate how the expenses vary in three possible scenarios. MA is very different regarding age and sex, with maximum levels in men between 35 and 69 years. The early death of younger individuals is more expensive, with a much lower SVL in old adults. The economic cost is much higher in the sample group with low physical activity, with an increase from 35 years and maximum values at 55-59 years. The economic costs varied, with 0.31% of the GDP for the minimum scenario, 0.09% for the medium scenario, and 0.03% for the maximum scenario. It is recommended to reinforce the development of public policies aimed at reducing sedentarism and physical inactivity in Spain.
Key words: physical activity; attitude; motivation; institutionalised elderly..

Introduction

Non-communicable diseases (NCD) cause 40 million deaths per year, which represent 70% of the deaths worldwide. These diseases are not transmitted among people, are of long-term duration, evolve slowly and generate high costs for healthcare systems. Every year, around 15 million people between 30 and 69 years of age die of NCD, prematurely. Cardiovascular diseases constitute most of the deaths by NCD (17.7 million per year), followed by cancer (8.8 million), respiratory diseases (3.9 million) and diabetes (1.6 million). These four groups of diseases account for over 80% of all the early deaths by NCD. Among the different types of NCD, the most important are cardiovascular diseases, diabetes and cancer (Molina, 2014). At the global level, of the 57 million people who died in 2008, 63% were due to NCD and over 80% of these deaths were caused by cardiovascular and respiratory diseases (World Heatlh Organization, 2010). These diseases are favoured by factors such as quick and unplanned housing development, globalisation of unhealthy lifestyles and the aging of the population. Modifiable behaviours such as smoking, physical inactivity, unhealthy diets and the uncontrolled consumption of alcohol increase the risk of NCD (World Health Organization, 2009).

In Spain, as in other countries in the same socio-economic environment, most deaths are caused by NCD, with three fifths of the total mortality being a consequence of cardiovascular diseases and cancer. Cardiovascular diseases represent the first cause of death in the Spanish population, with 29% of the total mortality in 2015 (Ministry of Health, 2017).

Although sedentarism and physical inactivity have been used as synonyms, they are different. A sedentary lifestyle refers to a physiological (activities within the continuum of energy expenditure measured in metabolic equivalents <1.5 METs), postural (sitting or in a reclined position) and contextual question (in wakefulness). Currently we could define sedentary lifestyle as the absence of ambulatory movement in any position (Stamatakis et al., 2018). On the other hand, physical inactivity or being inactive refers to those people who do not perform moderate to vigorous physical activity (3-5.9 METs is considered moderate, ≥6 METs

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vigorous) long enough that they can be recommended in the different guides for that purpose (van der Ploeg & Hillsdon, 2017).

According to the World Health Organization (WHO), physical inactivity is the fourth most important mortality risk factor; it has been attributed 5.5% of all deaths worldwide and is responsible for 32 million deaths per year (World Health Organization, 2009). This risk factor extends to other countries and has a great impact on the health of the world's population as a trigger of NCD.

A systematic analysis carried out by GBD Risk Factors Collaborators (2017), which provides an updated synthesis of the evidence of the exposure to the risk factors and the attributable load of the disease in different countries in the last 25 years, concluded that 1.6 million deaths per year can be attributed to insufficient physical activity.

In addition to being an important risk factor, physical inactivity generates a considerable economic expense for healthcare systems. In an analysis of physical inactivity and obesity in the public healthcare system of Ontario, Canada, it was estimated in 2009 that the economic cost was approximately $US 3.5 billion ($US 1.2 billion in direct costs and $US 2.34 billion in indirect costs) (Katzmarzyk, 2011). In Australia, simulation models were developed to calculate what would be the economic increase generated from a 10% decrease of physical inactivity. The results indicated that this reduction would translate into 6,000 less cases of new diseases, 2,000 less deaths, 114,000 working days saved and 180,000 days in household production, with a total saving of 96 million Australian dollars for the healthcare system (Cadilhac et al., 2011). In the United States, the economic costs related to medical resources used to attend to cases of sarcopenia (loss of muscle mass) were estimated with a study population of people over 60 years of age. In the year 2000, the direct costs derived from the medical attention attributable to sarcopenia were $US 18.5 billion ($US 10.8 billion for men and $US 7.7 billion for women), which represents around 1.5% of the total medical costs of that year (Janssen, Shepard, Katzmarzyk, & Roubenoff, 2004). Furthermore, there is solid scientific evidence to state that the direct costs attributable to physical inactivity are between 1% and 4% of the total costs in healthcare and the indirect costs are over twice as much (Janssen, 2012). Likewise, several studies show that interventions of physical activity are cost-effective (Muller-Riemenschneider, Reinhold, & Willich, 2009; Wu, Cohen, Shi, Pearson, & Sturm, 2011).

In turn, physical inactivity can lead to metabolic risk factors, which are the main risk factor of cardiovascular diseases. Metabolic risk factors contribute to four fundamental metabolic changes that increase the risk of NCD: the increase of blood pressure, overweight and obesity, hyperglycemia (high blood sugar levels), and hyperlipidemia (high concentrations of lipids in blood) (GBD, 2017; Suárez Carmona, Sánchez Oliver, & González Jurado, 2017)

In view of the above mentioned, the aim of the present study was to estimate the mortality and economic expenses caused by cardiovascular diseases attributable to physical inactivity in Spain.

Methodology

Calculation of the population attributable fraction (PAF) link to physical inactivity.

The relative risks (RR) estimated in a meta-analysis (Garcia, 2014) were used as input, along with the proportion of prevalence of this risk factor obtained from the microdata of the National Health Survey 2011-2012 (Ministry of Health and Consumption, 2013). The PAF can be expressed mathematically as:

$$PAF = \frac{P(D) - \sum_C P(D|\bar{C},\bar{E})P(C)}{P(D)} \qquad [1]$$

, where P(D) is the average probability of the disease in a population with exposed and unexposed people, and $\sum_C P(D|\bar{C},\bar{E})P(C)$ represents the conditional marginal probability of the disease in the absence of averaged exposure throughout the strata of other risk factors (Rockhill, Newman, & Weinberg, 1998). To estimate the PAFs, several formulas have used, and in this case, the following equation was applied for different categories of exposure as an empiric approach to the previous expression:

$$PAF = 1 - \frac{1}{\sum_{i=0}^{k}(p_i RR_i)} \qquad [2]$$

, where p_i is the proportion of the population that belongs to the level of exposure i, and RR_i is the relative risk in the exposure level i. The exposure levels were categorised in METs according to the meta-analysis used, establishing three scenarios: low physical activity (600-3999 min/week), medium physical activity (4000-7999 min/week), and high physical activity (>7999 min/week).

Estimation of mortality attributable to cardiovascular diseases associated with physical inactivity.

This was calculated using equation 3, as the product between the PAFs and the number of deaths caused by associated cardiovascular diseases:

$$MA_{s,e,naf} = Deaths_{s,e} \cdot PAF_{s,e,naf} \quad [3]$$

, where MA to the risk factor is the product of the number of deaths stratified by age (e) and sex (s) groups, times the PAFs stratified by groups of age, sex and level of exposure to the risk factor (level of physical activity). Given the fact that the meta-analysis does not separate the causes of death beyond cardiovascular diseases or cerebrovascular accidents (Garcia, 2014), it is not possible to separate the estimations of the economic costs by disease. Therefore, hypertensive diseases (I10-I15), heart ischemic diseases (I20-I25), other forms of heart disease (I30-I52), and cerebrovascular diseases (I60-I69) were considered, according to the International Classification of Diseases, 10th edition (Panamerican Health Organization, 2003), and based on the deaths by disease published by the National Institute of Statistics (NIS) (National Institute of Statistics,2015).

Valuation: productivity lost by cardiovascular deaths attributable to low physical activity.

The statistical value of life (SVL) was determined by following the human capital approach, by which statistical life is estimated by the productivity lost by early death:

$$PVFI_i = \sum_{j=i}^{99} p(alive)_i^j \cdot Income_j \cdot (1+g)^{j-i} \cdot \left(\frac{1}{1+r}\right)^{j-i} \quad [4]$$

The SVL can be determined by using the actuarial formula proposed in equation 4, where the productivity lost by early death is estimated with the labour income that an individual receives, deducing this to obtain the present value of the future income (PVFI). In this equation, *p*(alive) is the probability of the person with age *i* to be alive at age *j*, *Income* is the average labour income of the people of age *j*, *g* is the growth rate of the average income, and *r* is the deduction rate. The growth rate of the average labour income was calculated as the average growth value of the GDP per capita in the period of 2000-2016(Aguirre Botello, 2014; Escaño-Marín et al., 2017). An average deduction rate of 5% was selected for being moderate. The probability of survival was estimated by using the mortality tables of the NIS. To calculate the probability of survival of an individual of age *i* at age *i*+*n*, the following formula was used:

$$p(alive)_i^j = \frac{l(i+n)}{l(i)} \quad [5]$$

The total average income by age is the income that the individual would have perceived if he/she would have survived. To calculate this, the microdata from the Life Conditions Survey (LCS) of 2016 were used, of which the authors only employed the labour income for all the clusters weighted by their expansion factor. However, the income by gender was not differentiated since, otherwise, there would be a marked difference between the salaries for not considering the implicit household production, along with a lower participation of women in the job market and lower average salaries.

Then, a sensitivity was conducted proposing different scenarios, with the aim of evaluating how the outputs are modified (SVL or PVFI) when the inputs (growth rate of the average product, reduction rate) vary between age groups. To carry out this analysis, a simulation of Montecarlo was performed with 20,000 iterations. In this simulation, a triangular distribution was used, which allowed reflecting different scenarios with respect to the variability of the values selected. Regarding the inputs, a minimum limit of 1% and a maximum limit of 7% were established for the product growth rate. With respect to the reduction rate, a minimum limit of 3% and a maximum limit of 7% were established, as recommended by Harrison for sensitivity analyses in this type of studies (Harrison, 2010).

Economic costs associated with cardiovascular diseases attributable to physical inactivity.

The economic costs of early death associated with the loss of productivity attributable to physical inactivity can be calculated by using the following equation:

$$CMA_{s,e,naf} = MA_{s,e,naf} \cdot PVFI_e \quad [6]$$

, where $CMA_{s,e,naf}$ is the economic cost by early death associated with the loss of productivity attributable to scarce physical activity, stratified by groups of age (*e*), sex (*s*) and level of exposure to the risk factor, and $PVFI_e$ is the present value of the future income or SVL by age group.

Results

Figure 1 shows the mortality calculated for individuals with a low level of physical activity and stratified by sex and age. As can be observed, after the groups of 35-39 years of age, a gap begins to grow between the two curves (men and women), which reaches a maximum point in the group of 65-69 years, as a consequence of the large number of deaths in men.

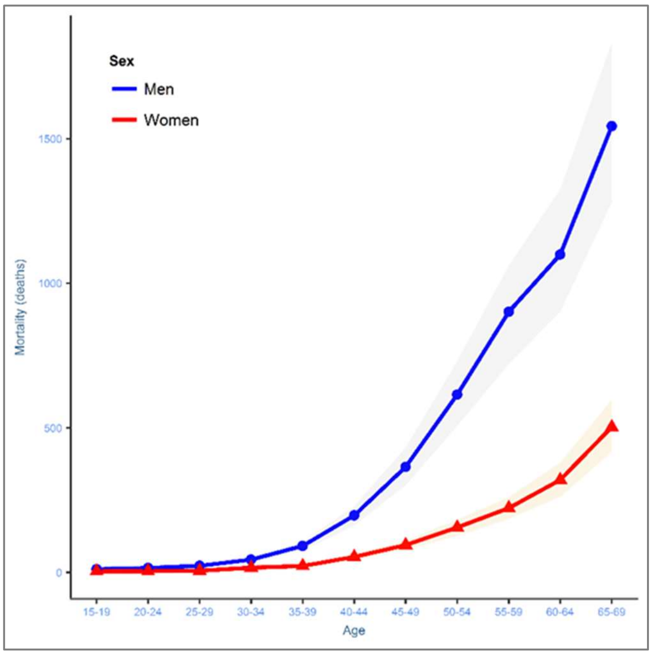

Fig. 1. Mortality, number of deaths, attributable by sex and age in Spain. *Source: compiled by author.*

Figure 2 shows the SVL over the average growth of the GDP per capita in the period of 2000-2016, for which an average reduction rate of 5% was selected for being moderate. As can be observed, the early death of the younger individuals is the most costly. By stratifying this group, it is shown that the largest cost by early death corresponds to male individuals between 15 and 19 years of age. On the other hand, in mature adults the SVLs are lower, since this group have less years of life ahead and also because their probability of survival decreases along with their expected income.

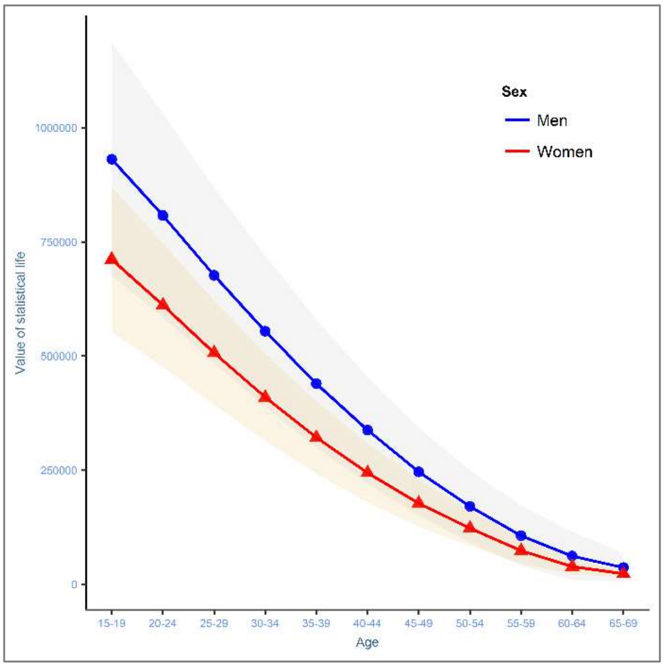

Figure 2. Statistical value of a life, expressed in thousands of euros, by groups of age and sex in Spain. *Source: compiled by author.*

Figure 3 shows the economic costs by early death associated with the loss of productivity attributable to cardiovascular diseases caused by physical inactivity, distributed in 3 levels of physical activity (according to METs) and age groups. The variation of the curves is caused by the interaction between the values of the RR, the prevalence proportion of the risk factor and the SVLs, which vary between younger individuals (who have a very high SVL and a low RR, even when they do not carry out any physical activity) and older adults. However, this graph only shows the variations of the SVL values at different ages, which does not occur with the RR (beyond the differences by level of physical activity), since these were not stratified by age. In the low level of physical activity (600-3999 METs), it can be observed that the economic cost is higher even at younger ages (18-24 years), with the curve increasing much more from 35 years and reaching a maximum value in the age group of 55-59 years. After reaching this maximum point, the SVL of the following age group (60-64 years) decreases considerably with respect to the previous group, and this decrease continues in the following groups. Although the difference between the group of low physical activity and the other two groups analysed (medium and high) is very high, the difference between the latter two is low. From all these findings, it was determined that the economic losses varied 0.31% of the GDP for the minimum scenario, 0.09% for the medium scenario, and 0.03% for the maximum scenario.

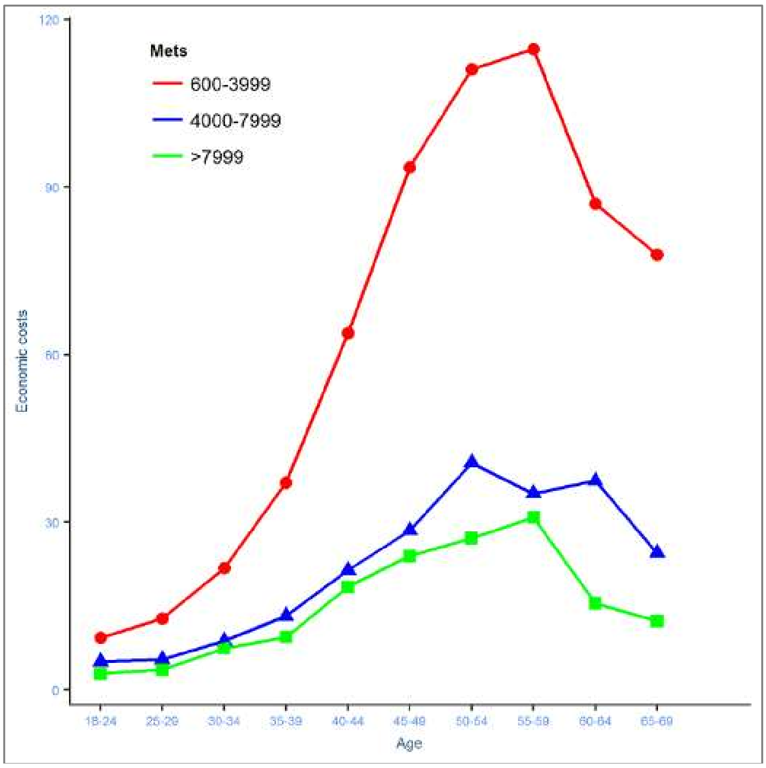

Fig. 3. Economic costs, expressed in millions of euros, by early death associated with the loss of productivity attributable to cardiovascular diseases linked to physical inactivity, by groups of age and level of physical activity in Spain. *Source: compiled by author.*

Discussion

Every year, non-communicable diseases cause 16 million early deaths. Thereby, the WHO urges to double the efforts (Chan, 2016). Since several years ago, insufficient physical activity has become an international concern. In 2014, around 23% of adults and 81% of teenagers (11 to 17 years of age) were not sufficiently active (World Health Organization, 2014).

The results obtained can be compared with those of other studies carried out in other countries that used the same method with other risk factors. Thus, in 2016 the economic impact of smoking on the healthcare systems of South America was estimated (Pichon-Riviere et al., 2016). Likewise, the Argentinian Drug Observatory calculated the economic cost of the abuse of psychoactive substances, establishing this at 0.91% of the GDP for smoking, 1.07% for the consumption of alcohol, and 2.93% for the consumption of legal and illegal drugs (Argentinian Drug Observatory, 2007). Following this line, with communicable diseases, the cost of the productivity loss due to deaths associated with aids in Argentina was estimated in 2011, which was 0.40% of the GDP (Avendaño, 2011). In the same manner, with similar numbers, there are Spanish studies that estimated the mortality attributable to the consumption of illegal drugs (Teresa Brugal et al., 2004).

According to the results obtained in the present study, MA to low and moderate physical activity varied between age groups and genders. The SVL was similar to that found in other studies (García & González-Jurado, 2017). The evaluation of the total costs indicates a great economic loss in both genders, and even in early ages when the level of physical activity is low. The results indicate an important load of mortality and costs attributable to cardiovascular diseases associated with physical inactivity in Spain; thus, it is recommended to reinforce the development of public policies targeted to reduce sedentarism and physical inactivity in Spain. To this end, it is essential to know how long it would take for a state intervention to generate positive results. In this sense, it is important to mention that there is substantial scientific evidence of a causal relationship between improvements in the cardiovascular profiles of individuals and the implementation of short-term programs of physical activity (Giada, Biffi, Agostoni, Anedda, Belardinelli, Carlon, Caru, et al., 2008; Giada, Biffi, Agostoni, Anedda, Belardinelli, Carlon, Carù, et al., 2008; Pedersen & Saltin, 2015). Physical inactivity and sedentarism, with sitting time being one of the key components, have been related to a higher prevalence of diseases and higher risk of mortality from any cause (Endorsed by The Obesity Society et al., 2016). Thus, in this way, we find the paradox that there are people who practice some sport but that the time dedicated and the intensity of this activity are not adequate to assume a protection factor (Ekelund et al., 2016), or on the other hand, finding individuals who can be considered physically active despite being sedentary (Cristi-Montero & Rodríguez, 2014). It would be convenient to determine whether sedentarism influences inactive people to estimate higher costs than more active people, making them fall into a vicious circle that is difficult to leave. Thus, some researchers analysed the influence of previous experiences with physical activities on the cost-profit calculation conducted by individuals. The costs of exercising were significantly higher for individuals with less experience in exercising than for those with more experience, since the former might have had a less positive experience with exercise and more positive with the inactive leisure activities (Hagberg & Lindholm, 2010).

The importance of the present work lies in the estimation of mortality and the costs of cardiovascular deaths attributable to physical inactivity in Spain. In this sense, it is necessary to expand the research about the analysis of cost-profit in these diseases or other diseases related to physical inactivity and sedentarism, and carry out subsequent evaluations to determine whether the different strategies and policies established are improving the current framework. Regarding limitations, this study did not consider the costs generated from exercising, the direct costs generated from medical care, or the economic loss generated by the individuals who are excluded from the job market due to disabilities derived from cardiovascular diseases.

Conclusions

The results of this study suggest that physical inactivity poses an important economic and mortality load for the population of Spain and, as a consequence, it is recommended to develop research lines that explore the factors that affect the practice of physical activity, and to adopt efficient measures targeted to decrease this risk factor through better policies designed to reduce sedentarism and physical inactivity.

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