# The difference in risk of chronic pulmonary disease morbidity and mortality between former elite athletes and ordinary men in Finland.

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Key words: SMOKING, OBSTRUCTIVE PULMONARY DISEASE, ASTHMA, EMPHYSEMA, CHRONIC BRONCHITIS, COPD, CHRONIC DISEASE, COHORT STUDY, FORMER ATHLETE(S), PHYSICAL ACTIVITY.

Word count: 3193

**ABSTRACT**

**Introduction:** The impact of a history of competitive sports on later smoking behavior and occurrence of chronic pulmonary diseases is poorly known. We investigated how a history of elite level sports predicted later pulmonary disease morbidity and mortality.

**Methods:** Chronic pulmonary disease incidence were assessed from national hospital and cause-of-death registers from 1970 to 2015 among Finnish male former elite athletes (n=2078) and matched controls (n=1453) alive in 1970 (mean age 45.0 years). Hazard ratios (HRs) were calculated by Cox proportional hazards model. In 1985, cohort members reported on their smoking habits, engagement in physical activity/sports and physician-diagnosed chronic diseases.

**Results:** The risk of any chronic pulmonary disease or death was lower among former athletes than controls (age-adjusted HR 0.61; 95% CI 0.46-0.83). The risk was significantly lower among endurance (HR 0.54), mixed (HR 0.61), and power sports athletes (HR 0.66) compared to controls. The age- and smoking pack-year-adjusted HRs of incident diseases from the time of the 1985 questionnaire until end of follow-up in former athletes was 0.58 (95% CI 0.37-0.93) compared to controls. In 1985 athletes smoked less and their cumulative smoking quantity was lower than that of controls. Former athletes were more physically active and self-reported less physician-diagnosed emphysema.

**Conclusions:** The risk of any chronic pulmonary disease was lower among former athletes than controls even after considering smoking status and cumulative smoking quantity. Ability to compete at the highest level of sports in young adulthood associates with a reduced risk of pulmonary disease in later life.

**Key words:** SMOKING, OBSTRUCTIVE PULMONARY DISEASE, ASTHMA, EMPHYSEMA, CHRONIC BRONCHITIS, COPD, CHRONIC DISEASE, COHORT STUDY, FORMER ATHLETE(S), PHYSICAL ACTIVITY.

## INTRODUCTION

There is a widespread scientific and public health policy consensus that behavioral factors such as cigarette smoking, hazardous alcohol drinking and physical inactivity are major contributors to morbidity and mortality.[1-2] The healthcare expenditure on treating smoking attributable diseases is 5.7% of global health expenditure, a heavy economic burden that occurs particularly in Europe and North America.[3]

Smoking is associated with less leisure-time physical activity in cross-sectional and longitudinal studies.[4-6] Longitudinally habitual physical inactivity during late adolescence as compared to continuous physical activity through adolescence, predicts higher prevalence of smoking during young adulthood even after familial, including genetic factors are considered.[7] Studies have shown that current athletes smoke less than non-athletes.[8-10] Elite athletes also smoke less after concluding their competitive career.[11-13]

Cigarette smoke exposure, either directly or indirectly, has been highly correlated with the development of chronic obstructive pulmonary disease (COPD) and mortality[14] and smoking is well-established as the main cause of COPD. COPD is a heterogeneous collection of diseases with differing causes, pathogenic mechanisms, and physiological effects.[15] Conventionally COPD is subdivided into several entities, including emphysema and chronic bronchitis.[16] COPD was the third leading cause of death in the United States in 2013.[17]

Asthma is also a heterogenic and multifactorial disease which has different symptoms.[18] The Lancet Commission argued that asthma is not an adequate name, underlying treatable traits should be recognized, and comorbidities, lifestyle and environmental factors should be taken into account.[18] In the clinical setting, patients who present with a combination of COPD and asthma related traits are quite common.[19-21] However, there is also evidence that inflammatory processes differ in asthma and COPD and findings suggest that there is no strong common genetic component in asthma and COPD,[22] but a genetic correlation between COPD and asthma has found.[23]

Asthma, airway hyperresponsiveness (AHR), and exercise-induced bronchoconstriction (EIB) appear to be more common in elite athletes than less-trained controls.[24-25] Correspondingly, epidemiologic studies suggest that self-reported and physician-diagnosed asthma are twice as common in Finnish athletes[26] and elite Norwegian athletes[27] than in randomly selected age-matched and sex-matched control populations. The higher prevalence of asthma reported in athletes may be a result of overdiagnosis, particularly because a diagnosis of asthma is often made on the basis of the history alone[28] and athletes often experience the symptoms during intensive exercise only.

Kujala et al (1996) reported that the lifetime occurrence of asthma or other pulmonary diseases was not increased in former elite athletes, and exercise alone, even in a cold environment, was not associated with a greater prevalence of asthma in later life.[29] Cohort studies have also revealed that physical activity decreases the number of exacerbations and short-acting bronchodilator use among COPD patients,[30] whereas physical inactivity may increase COPD patient`s perception of dyspnea.[31]

Prevention of chronic pulmonary diseases should be a major public health goal.[15,18] Furthermore, we know very little about the long-lasting effects of a history of competitive sports activity during young adulthood. Peak performance during competitive sports requires excellent lung function, but is inferred pulmonary health in young adulthood related to occurrence of chronic pulmonary disease in later life? In our study we especially focused on hospitalizations and deaths for selected chronic pulmonary diseases, with several decades longer follow-up time compared to our previous study of the same cohort.[29] We had three aims, the first of which was to examine how former competitive sports career and smoking was associated with the incidence and mortality of any chronic pulmonary diseases from 1970 and the time of the 1985 questionnaire until end of follow-up. Secondly, we compared these risks between different sports groups.

Thirdly, we studied how different factors, such as physical activity, were associated with smoking among former athletes after their active athletic career.

## METHODS

### Participants and participants involvement

An original cohort of former elite athletes (n=2657) was formed by identifying men who had represented Finland between 1920 and 1965 at least once at the Olympic Games, European or World championships, or international contests between two or three countries.[32] A control cohort (n=1712) was selected from Finnish men who at the age of 20 years had been identified healthy in the medical inspection for enlisting in ordinary military service (class A1, which means fully fit for ordinary military service). The control cohort was formed by matching the same age groups and area of residence with the former elite athletes. After first finding the athlete in the register, the selection of each control subject was done. The control subject was chosen nearest the A1 conscript listed to the athlete. This procedure was carried out in the years 1978-1979, when 85.3 % of the athletes had been identified.[32]

Participants who had died before the register-based follow-up started in January 1, 1970 were excluded from this study. Thus, the final study population (n=3531) consisted of 2078 former male athletes and 1453 matched control participants (Table 1 and Figure 1). Male former elite athletes are divided into three groups according to the type of training needed to achieve optimal results[33]: endurance (n=359), mixed (n=924) and power sports (n=795).

To adjust for occupational loading, the participants were classified into five socioeconomic groups based on occupation: upper white collar, lower white collars, skilled (blue) collars, unskilled workers and farmers[34] according to the occupation in which they had practiced the longest (for classification see Table, Supplemental Digital Content 1). This classification also reflects the socioeconomic status (SES) of the participants. The socioeconomic group distribution of athletes differed from that of controls ($p<0.001$, $\chi^2$ -test). Occupational data were collected partly from the Central Population Registry of Finland and partly from questionnaires, asking for the occupation in which they had been active the longest.

The register-based follow-up of hospitalizations started in January 1, 1970 and ended in December 31, 2015. Participants who had hospital admissions for chronic pulmonary diseases were identified from the National Hospital Discharge Register according to ICD-codes (ICD-8, ICD-9 or ICD-10). There are changes in diagnostic category, in ICD-10 COPD is defined as other chronic obstructive pulmonary disease (J 44.0), but earlier ICD-codes (ICD-8, ICD-9) do not include this specific code. Chronic pulmonary diseases were categorized into five main groups: chronic bronchitis, emphysema, other obstructive pulmonary diseases, asthma and bronchiectasia (for all details see Table, Supplemental Digital Content 2). The primary diagnosis was used to determine the reason for hospitalization, and the secondary diagnoses were ignored in the analysis. Participants who died from chronic pulmonary diseases (as the underlying cause of death) were identified from the National Death Register of Statistics Finland (cause of death chronic bronchitis, emphysema and asthma, grouped according to Statistics Finland internal codes 33 and 34; http://www.stat.fi/til/ksyyt/2005/ksyyt_2005_2006-10-31_luo_002.html).

Participants were not involved in setting the research question, the outcome measures or study design. Before taking part in the study all the participants gave informed consent by returning the questionnaires, which were accompanied by a cover letter explaining the purpose of the study. This study was conducted according to good clinical and scientific practice and the Declaration of Helsinki. Approval for register data collection was given by the Ministry of Social Affairs and Health in Finland, National Institute for Health and Welfare, and Statistics Finland.

**Questionnaire study 1985**

In 1985 a postal questionnaire eliciting information on discontinuation of sports career, socio-demographic factors (including occupational loading), health-related lifestyle habits, such as smoking and physical activity, and physician-diagnosed chronic diseases, was sent to the surviving cohort members (total n=2528, athletes n=1518 and controls n=1010).[29] Former elite athletes (n=1248, 82% response rate) and controls (n=759, 76%), who answered the smoking-related questions, were included in the statistical analysis. The response rate was 67.2% (n=119) among those participants alive in 1985 who had admissions to hospital at any time for any chronic pulmonary disease or death, and among this subgroup the response rate was higher among former athletes 71.1% (n=59) than among controls 63.8% (n=60).

The volume of physical activity (MET-hours/day, MET, metabolic equivalent) in 1985 was computed from the responses to three structured questions, using a previously validated method.[35] MET-hours/week was categorized into tertiles of physical activity: 1=MET-hours/day ≤0.9 (less active), 2= 0.9< MET-hours/day ≤3.2 (moderate active), 3= MET-hours/day >3.2 (highly active). Engagement in competitive sports was dichotomized. The term "discontinued sports" means that the athlete had retired from competitive sports based on questions in the 1985 questionnaire.

Smoking exposure was determined by the pack-years in 1985. It was calculated by multiplying the number of packs of cigarettes smoked daily by the number of years the person has smoked (https://www.cancer.gov/publications/dictionaries/cancer-terms/def/pack-year).

The smoking status of the participants was classified into five categories from responses to a detailed smoking history: never, former, current or occasional smokers and other (no exact information about smoking). Never smokers were men who had smoked no more than 5 to 10 packs of cigarettes (or equivalent of other tobacco product) throughout their lifetime. Former smokers were participants who had smoked regularly and more than 5-10 packs of cigarettes in their lifetime but have quit. Participants were classified as current, daily smokers if they smoked regularly, i.e. daily or almost daily at the time. Occasional smokers were men who have smoked greater than 5 to 10 packs of cigarettes in their lifetime but were not regular smokers (for more details see Table, Supplemental Digital Content 3). For some analyses, we combined daily and occasional smokers as current smokers.

A history of physician-diagnosed chronic diseases was asked as dichotomous variables, such as asthma, emphysema and chronic bronchitis.

**Statistical analysis**

The descriptive data are presented as the mean and standard deviation (SD) or 95% confidence intervals (CI) if distributed normally; otherwise the descriptive data are shown as the median and range. The differences in the distributions of the categorical variables were examined using cross-tabulations with the Chi-square ($\chi^2$) -test.

The follow-up of hospitalization and deaths started on January 1, 1970 and continued until the end of 2015, or until the date of hospitalization due to first chronic pulmonary disease event, emigration or date of death, whichever date came first. The primary event of incident chronic pulmonary disease was defined as the first recorded hospital episode or of death from any chronic pulmonary disease. Furthermore, incidence and mortality of any chronic pulmonary diseases were examined from the time of the 1985 questionnaire until end of follow-up.

A Cox proportional hazards model was used to calculate age-, SES- and smoking pack-year -adjusted hazard ratios (HRs) with their 95% CIs for incidence of chronic pulmonary disease between former athletes and controls. Time-invariant covariates were included to the analysis: age at entry and sports groups. Post hoc analysis taking into account the number of comparisons was used to compare statistical differences between specific sports groups. Participants still alive at the end of follow up, those who emigrated, and those who died from any other cause, were censored. The Cox regression assumptions were tested by using Schoenfeld residuals (ph-test in Stata) and also by plotting.

The 1985 questionnaire data was analyzed using non-parametric Kruskal-Wallis-test and using the Dunn-Bonferroni approach for post hoc testing in pairwise comparisons for more than two groups ($p<0.05$), because some of the variables were not normally distributed and variances were not equal. The Mann-Whitney-U-test was used to compare differences between sports groups and controls ($p<0.05$). Homogeneity of variances were assessed using Levene`s test and normality using Kolmogorov-Smirnov`s test ($p<0.05$).

P-values <0.05 were considered statistically significant. Statistical analyses were performed using SPSS statistical software (version 24.0 for Windows; SPSS Inc., Chicago, IL) and Stata 14.0 (Stata Corp, College Station, Texas, USA).

## RESULTS

The mean age of the athletes at the start of follow-up in 1970 was 45.4 years, and 44.3 years among controls. Altogether, 4.0% (n=83) of former athletes and 6.5% (n=94) of controls were admitted to hospital for any chronic pulmonary disease during the 45-year follow-up period. The most common reasons for admissions were asthma (athletes 1.7% (n=35), controls 2.5% (n=37)) and chronic bronchitis (athletes 0.5% (n=10), controls 1.4% (n=20)) (Table 2). Total days in hospital were 1693 among former athletes and 8761 among controls, mean of total days in hospital/total exposure years (days/years) was 3.5 (95% CI 0.2-6.9) among former athletes and 7.2 (95% CI 1.7-12.7) among controls (Table 2). The median total number of days in hospital was 14 (range 2-225) in all former athletes and 17 (1-6141) in controls; however, 20 former athletes and 22 controls died of chronic pulmonary disease without being hospitalized at least once (Table 2). The mean age at the first admission of any chronic pulmonary disease was 68.2 (13.7) years for the former athletes and 66.9 (12.2) years for the controls (Table 2).

The age-adjusted hazard ratios (HRs) for incidence of overall hospitalization or death due to chronic pulmonary disease in former athletes was 0.61 (95% CI 0.46-0.83, p=0.001) compared to controls (Table 3). Correspondingly, age- and SES-adjusted hazard ratios (HRs) for incidence of overall hospitalization or death due to chronic pulmonary disease in former athletes was 0.62 (95% CI 0.45-0.86, p=0.004) compared to controls (Table 3). However, no statistically significant differences were observed between former athletes and controls in the analysis of different main diagnosis groups separately (Table 3).

In an additional analysis by sports category, compared to controls statistically significant age-adjusted HRs were 0.54 (95% CI 0.31 - 0.96) for endurance sports athletes, 0.61 (95% CI 0.42 - 0.89) for mixed sports athletes and 0.66 (95% CI 0.44 - 0.98) for power sports athletes (Table 3). Correspondingly, the age- and SES-adjusted risk of chronic pulmonary diseases was higher among controls compared to endurance and power sports athletes (p<0.05) (Table 3).

No differences in incidence were observed between those who did not respond to 1985 questionnaire study and respondents, among all participants (HR=1.10, 95% CI 0.78-1.53, p=0.60), among former athletes (HR=1.01, 95% CI 0.61-1.66, p=0.98) and among controls (HR=1.34, 95% CI 0.84-2.13, p=0.21).

**The 1985 questionnaire data**

Former athletes smoked less than controls (p<0.001). Among controls 27.8% were current smokers compared with 16.1% among the former athletes, with 10.1% of endurance, 17.0% of mixed and 17.8% of power sports athletes being current smokers (For more details see Table, Supplemental Digital Content 3).

Mean pack-years was higher among those controls 17.0 (95% CI 15.7-18.3) than former athletes 9.6 (95% CI 8.7-10.5), who have ever smoked during their lifetime ($p<0.001$).

The age- and pack-year-adjusted HRs of incident diseases from the time of the 1985 questionnaire until end of follow-up in former athletes was 0.59 (95% CI 0.37-0.93, $p=0.024$) compared to controls; those with incident disease prior to 1985 or reported physician diagnoses of asthma, emphysema and chronic bronchitis were excluded from this analysis (For more details see Table, Supplemental Digital Content 4). The age-adjusted HR of incident pulmonary disease in current smokers was 4.89 (95% CI 1.98-11.78, $p=0.001$) compared to never smokers, and there was no evidence of a smoking status by athlete status interaction on disease risk ($p=0.25$) (For more details see Table, Supplemental Digital Content 5).

Mean MET-hours/week in 1985 were significantly higher among former athletes than controls ($p<0.001$). One sixth (15.6%, n=189) of former athletes and 12.5% (n=35) of controls participated in competitive sports in 1985 ($p<0.001$). Athletes self-reported less physician-diagnosed emphysema than controls ($p<0.05$) (for more details see Table, Supplemental Digital Content 6).

## DISCUSSION

There is lack of studies focused on the risk of chronic pulmonary diseases among former athletes several decades after their peak sporting performance. Our study showed that the risk of any chronic pulmonary disease or death was lower among former athletes than controls. Accordingly, the risk was lower among endurance, mixed or power sports athletes compared to controls. Some studies have shown that the prevalence of asthma is increased in elite athletes.[24-25] Correspondingly, epidemiologic studies suggest that self-reported and physician-diagnosed asthma are twice as common in Finnish athletes[26] and elite Norwegian athletes[27] than control populations. The higher prevalence of asthma reported in athletes may be a result of overdiagnosis, particularly because a diagnosis of asthma is often made on the basis of the history alone.[28] Furthermore, respiratory symptoms may occur when exercising at high intensities which is common in athletes but uncommon in non-athletes. Although if non-athletes also exercise at high intensities, respiratory symptoms would probably occur more commonly. Former athletes smoked less than controls, as we have also reported earlier.[11-13] Our findings were consistent with other studies that have shown current athletes smoke less than non-athletes.[8-10]

This long-term follow-up study revealed new information on the long-term risk of chronic obstructive pulmonary diseases morbidity and mortality among former athletes. This study extended a previous study on the same cohort[29] which was based on questionnaire data and a nationwide reimbursable medication register. The use of the valid register data covering all participants was the strength of this study, data was specific but not sensitive concerning mild symptoms. Self-reported data on health-related behaviors include known limitations, but the self-reported smoking status has shown to be valid and reliable reflecting the social acceptance of smoking at that time.[36] Although questionnaire response rates were lower in individuals with chronic obstructive pulmonary diseases-related hospitalizations, the risk for bias in comparing the athlete group to non-athlete group was low.

Furthermore, there may have been selection bias at the beginning of our study as persons with suboptimal ventilatory function as young adults may have been incapable of becoming top athletes in endurance sports, thus reducing the prevalence of later chronic pulmonary disease. Furthermore, there is lack of consensus whether vigorous physical activity in a cold environment, which is common in Finland for several months of the year, predisposes to chronic pulmonary diseases. Some studies have found that persons who routinely perform strenuous exercise in cold conditions have a high prevalence of chronic airway inflammation and hyperreactivity,[37] also cold weather exercise can lead to asthma-like airway disease.[38]

Because former athletes are a selected group and they competed at top-level before 1965, we do not know exactly how well the results can be generalized to today’s elite athletes or athletes who had competed in lower level, to non-athletes or to women. Thus, we cannot conclude whether the decreased risk of pulmonary disease is due to selection of persons with extraordinary lung function to start with, and hence high reserve of that function in later life, or does training in adolescence and young adulthood promote development of lung function, yielding greater lung health in later life. Studies have suggested that interactions between genetic factors and early environmental exposures patterns may explain the early development of chronic obstructive lung diseases.[39] Particularly genome-wide association studies (GWASs) have been identifying genetic variants in the development of lung function in early life and later progression to asthma and COPD, but they account for at most a modest fraction of variability in lung function. There are still challenges to understand effects of genetic variants on health and disease and how they contribute opportunities for therapeutic intervention.[40]

## Conclusions

The risk of any chronic pulmonary disease was lower among former athletes than controls even after considering smoking status and cumulative smoking quantity. Former athletes were more physically active, were less often smokers, had started smoking later and smoked less than controls. Furthermore, former athletes reported less physician-diagnosed emphysema than controls. In conclusion, ability to compete at the highest level of sports in young adulthood associates with a reduced risk of pulmonary disease in later life.

**Contributors**

SS, JK and UMK collected the data. TKK and UMK analyzed the data. TKK drafted the manuscript. All authors contributed to study design, and the revision of the manuscript, and accepted the final version. The authors apologize for not being able to cite all the noteworthy work in this area because of constraints on space.

**Funding**

This study was funded by University of Jyväskylä and Helsinki, Urheiluopistosäätiö, and there was no conflict of interests. JK has been supported by the Academy of Finland (grants 265240, 308248, 312073).

**Competing interest**

None.

**Ethical approval**

This study was conducted according to good clinical and scientific practice and the Declaration of Helsinki. The authors declare that the results of this study are presented clearly, honestly, and without fabrication, falsification or inappropriate data manipulation. Approval for register data collection was given by the Ministry of Social Affairs and Health in Finland, and Statistics Finland. All the participants gave informed consent by returning the questionnaires, which were accompanied by a cover letter explaining the purpose of the study.

**Data sharing**

The former athletes are well known persons in Finnish society; hence the data cannot be openly shared. Researchers are encouraged to contact the authors and we will make every effort to accommodate additional analyses.

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## List of Tables



## List of Figures

**Table 1.** Number of participants at entry to study and still alive in January 1, 1970, 1985 and December 31, 2015.

| Sports groups | Participants at entry | Participants alive in 1970 | | Participants alive in 1985 | | Questionnaire responders in 1985 | | Participants alive in 2015 | |
|---|---|---|---|---|---|---|---|---|---|
| | (N) | (N) | Mean age (SD) | (N) | Mean age (SD) | (N) | Mean age (SD) | (N) | Mean age (SD) |
| **1. Endurance** | 437 | 359* | 48.9 (13.0) | 287 | 64.2 (13.0) | 226 | 60.6 (11.1) | 110 | 78.2 (11.3) |
| **2. Mixed sports** | 1046 | 924† | 43.1 (13.2) | 785 | 58.3 (13.2) | 607 | 54.9 (10.8) | 411 | 76.1 (10.8) |
| **3. Power sports** | 941 | 795‡ | 46.5 (13.2) | 607 | 61.8 (13.2) | 443 | 57.5 (10.7) | 251 | 74.3 (12.4) |
| **All athletes** | 2424 | 2078 | 45.4 (13.3) | 1679 | 60.6 (13.3) | 1276 | 56.8 (11.0) | 772 | 75.8 (11.6) |
| **Controls** | 1712 | 1453 | 44.3 (13.0) | 1149 | 59.6 (13.0) | 777 | 55.0 (10.3) | 494 | 73.8 (13.4) |
| **Total** | **4136** | **3531** | **45.0 (13.2)** | **2828** | **60.2 (13.2)** | **2053** | **56.1 (10.8)** | **1266** | **75.0 (12.4)** |

Data are numbers in 1970.
*Long distance running 162, middle distance running 79, cross country skiing 118.
†Soccer 262, ice hockey 154, basketball 84, high jump 46, pole vault 54, long jump 35, triple jump 34, hurdling 85, short distance running 123, decathlon 45.
‡Weightlifting 115, boxing 253, wrestling 261, shot put 38, discus 35, javelin 56, hammer 37.

**Table 2.** Number of participants in chronic pulmonary diseases main diagnosis groups, total days in hospital, median of days in hospital, mean of exposure time and mean of total days in hospital/total exposure time among former athletes and controls.

| Sports groups | Asthma* | Chronic bronchitis* | Emphysema* | Other obstructive chronic pulmonary disease* | Bronchi-ectasia* | Any chronic pulmo-nary disease* | Chronic pulmonary disease-related death (no hospitali-zation before) | Any chronic pulmonary disease-related disease or death | Total days in hospital for any chronic pulmonary disease during follow-up | Median of days in hospital for chronic pulmonary disease (range) | Mean of exposure years (95% CI) | Mean of total days in hospital / Total exposure years (days/ years) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Endurance** | 6 | 1 | 1 | 3 | 2 | 13 | 1 | 14 | 302 | 14.0 (5-61) | 29.3 (27.8-30.8) | 9.8 (9.1-28.7) |
| **Mixed sports** | 14 | 7 | 0 | 6 | 0 | 27 | 11 | 38 | 458 | 10.0 (2-82) | 33.1 (32.2-34.1) | 2.1 (0.4-4.7) |
| **Power sports** | 15 | 2 | 0 | 5 | 1 | 23 | 8 | 31 | 933 | 19.0 (3-225) | 28.3 (27.2-29.3) | 2.2 (0.7-3.7) |
| **All athletes** | 35 | 10 | 1 | 14 | 3 | 63 | 20 | 83 | 1693 | 14.0 (2-225) | 30.6 (30.0-31.2) | 3.5 (0.2-6.9) |
| **Controls** | 37 | 20 | 1 | 10 | 2 | 70 | 24 | 94 | 8761 | 17.0 (1-6141) | 29.5 (28.7-30.2) | 7.2 (1.7-12.7) |
| **Total** | 72 | 30 | 2 | 24 | 5 | 133 | 44 | 177 | 10454 | 15.0 (1-6141) | 30.1 (29.6-30.6) | - |

*Number of participants who have any chronic pulmonary disease. One participant may have more than one main diagnosis if there are more than 1 hospital admissions.

**Table 3.** Age- and socioeconomic status (SES) -adjusted hazard ratios (HRs) for incidence of chronic pulmonary disease from January 1, 1970 to December 31, 2015 among former athletes compared to controls and mean (SD) age at first admission.

| | | | Age -adjusted | | | | Age- and SES-adjusted | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sports groups** | **N of participants with incident disease** | **Mean age (SD) at disease onset** | **HR** | **95.0% Confidence Interval Lower** | **Upper** | **P-value*** | **HR** | **95.0% Confidence Interval Lower** | **Upper** | **P-value*** |
| Endurance (n=359) | 14 | 69.1 (17.4) | 0.544 | 0.310 | 0.955 | 0.034 | 0.472 | 0.266 | 0.837 | 0.010 |
| Mixed sports (n=924) | 38 | 68.2 (12.1) | 0.612 | 0.419 | 0.894 | 0.011 | 0.715 | 0.470 | 1.089 | 0.118 |
| Power sports (n=795) | 31 | 67.8 (14.0) | 0.655 | 0.436 | 0.984 | 0.041 | 0.631 | 0.414 | 0.961 | 0.032 |
| All athletes (n=2078) | 83 | 68.2 (13.7) | 0.614 | 0.457 | 0.826 | 0.001 | 0.621 | 0.450 | 0.859 | 0.004 |
| Controls (n=1453) | 94 | 66.9 (12.2) | 1.000 | - | - | - | 1.000 | - | - | - |
| Total (n=3531) | 177 | 67.6 (13.0) | - | - | - | - | - | - | - | - |

*p-values for statistical differences between sports groups and controls from Cox regression analysis.