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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.

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.

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1 INTRODUCTION

2

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

7

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

13

14 Cigarette smoke exposure, either directly or indirectly, has been highly correlated with the development of
15 chronic obstructive pulmonary disease (COPD) and mortality¹⁴ and smoking is well-established as the main
16 cause of COPD. COPD is a heterogeneous collection of diseases with differing causes, pathogenic
17 mechanisms, and physiological effects.¹⁵ Conventionally COPD is subdivided into several entities,
18 including emphysema and chronic bronchitis.¹⁶ COPD was the third leading cause of death in the United
19 States in 2013.¹⁷

20

21 Asthma is also a heterogenic and multifactorial disease which has different symptoms.¹⁸ The Lancet
22 Commission argued that asthma is not an adequate name, underlying treatable traits should be recognized,
23 and comorbidities, lifestyle and environmental factors should be taken into account.¹⁸ In the clinical setting,
24 patients who present with a combination of COPD and asthma related traits are quite common.¹⁹⁻

25 ²¹ However, there is also evidence that inflammatory processes differ in asthma and COPD and findings

26 suggest that there is no strong common genetic component in asthma and COPD,²² but a genetic correlation
27 between COPD and asthma has found.²³

28
29 Asthma, airway hyperresponsiveness (AHR), and exercise-induced bronchoconstriction (EIB) appear to be
30 more common in elite athletes than less-trained controls.²⁴⁻²⁵ Correspondingly, epidemiologic studies
31 suggest that self-reported and physician-diagnosed asthma are twice as common in Finnish athletes²⁶ and
32 elite Norwegian athletes²⁷ than in randomly selected age-matched and sex-matched control populations. The
33 higher prevalence of asthma reported in athletes may be a result of overdiagnosis, particularly because a
34 diagnosis of asthma is often made on the basis of the history alone²⁸ and athletes often experience the
35 symptoms during intensive exercise only.

36
37 Kujala et al (1996) reported that the lifetime occurrence of asthma or other pulmonary diseases was not
38 increased in former elite athletes, and exercise alone, even in a cold environment, was not associated with a
39 greater prevalence of asthma in later life.²⁹ Cohort studies have also revealed that physical activity
40 decreases the number of exacerbations and short-acting bronchodilator use among COPD patients,³⁰
41 whereas physical inactivity may increase COPD patient's perception of dyspnea.³¹

42
43 Prevention of chronic pulmonary diseases should be a major public health goal.^{15,18} Furthermore, we know
44 very little about the long-lasting effects of a history of competitive sports activity during young adulthood.
45 Peak performance during competitive sports requires excellent lung function, but is inferred pulmonary
46 health in young adulthood related to occurrence of chronic pulmonary disease in later life? In our study we
47 especially focused on hospitalizations and deaths for selected chronic pulmonary diseases, with several
48 decades longer follow-up time compared to our previous study of the same cohort.²⁹ We had three aims, the
49 first of which was to examine how former competitive sports career and smoking was associated with the
50 incidence and mortality of any chronic pulmonary diseases from 1970 and the time of the 1985
51 questionnaire until end of follow-up. Secondly, we compared these risks between different sports groups.

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

55 **METHODS**

57 **Participants and participants involvement**

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

69 Participants who had died before the register-based follow-up started in January 1, 1970 were excluded
70 from this study. Thus, the final study population (n=3531) consisted of 2078 former male athletes and 1453
71 matched control participants (Table 1 and Figure 1). Male former elite athletes are divided into three groups
72 according to the type of training needed to achieve optimal results³³: endurance (n=359), mixed (n=924) and
73 power sports (n=795).

75 To adjust for occupational loading, the participants were classified into five socioeconomic groups based on
76 occupation: upper white collar, lower white collars, skilled (blue) collars, unskilled workers and farmers³⁴
77 according to the occupation in which they had practiced the longest (for classification see Table,

78 Supplemental Digital Content 1). This classification also reflects the socioeconomic status (SES) of the
79 participants. The socioeconomic group distribution of athletes differed from that of controls ($p < 0.001$, χ^2 -
80 test). Occupational data were collected partly from the Central Population Registry of Finland and partly
81 from questionnaires, asking for the occupation in which they had been active the longest.

82
83 The register-based follow-up of hospitalizations started in January 1, 1970 and ended in December 31,
84 2015. Participants who had hospital admissions for chronic pulmonary diseases were identified from the
85 National Hospital Discharge Register according to ICD-codes (ICD-8, ICD-9 or ICD-10). There are
86 changes in diagnostic category, in ICD-10 COPD is defined as other chronic obstructive pulmonary disease
87 (J 44.0), but earlier ICD-codes (ICD-8, ICD-9) do not include this specific code. Chronic pulmonary
88 diseases were categorized into five main groups: chronic bronchitis, emphysema, other obstructive
89 pulmonary diseases, asthma and bronchiectasia (for all details see Table, Supplemental Digital Content 2).
90 The primary diagnosis was used to determine the reason for hospitalization, and the secondary diagnoses
91 were ignored in the analysis. Participants who died from chronic pulmonary diseases (as the underlying
92 cause of death) were identified from the National Death Register of Statistics Finland (cause of death
93 chronic bronchitis, emphysema and asthma, grouped according to Statistics Finland internal codes 33 and
94 34; http://www.stat.fi/til/ksyyt/2005/ksyyt_2005_2006-10-31_luo_002.html).

95
96 Participants were not involved in setting the research question, the outcome measures or study design.
97 Before taking part in the study all the participants gave informed consent by returning the questionnaires,
98 which were accompanied by a cover letter explaining the purpose of the study. This study was conducted
99 according to good clinical and scientific practice and the Declaration of Helsinki. Approval for register data
100 collection was given by the Ministry of Social Affairs and Health in Finland, National Institute for Health
101 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 \leq 0.9 (less active), 2= 0.9< MET-hours/day \leq 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

130 smoked regularly and more than 5-10 packs of cigarettes in their lifetime but have quit. Participants were
131 classified as current, daily smokers if they smoked regularly, i.e. daily or almost daily at the time.
132 Occasional smokers were men who have smoked greater than 5 to 10 packs of cigarettes in their lifetime but
133 were not regular smokers (for more details see Table, Supplemental Digital Content 3). For some analyses,
134 we combined daily and occasional smokers as current smokers.

135

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

138

139 **Statistical analysis**

140

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

145

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

152

153 A Cox proportional hazards model was used to calculate age-, SES- and smoking pack-year -adjusted
154 hazard ratios (HRs) with their 95% CIs for incidence of chronic pulmonary disease between former athletes
155 and controls. Time-invariant covariates were included to the analysis: age at entry and sports groups. Post

156 hoc analysis taking into account the number of comparisons was used to compare statistical differences
157 between specific sports groups. Participants still alive at the end of follow up, those who emigrated, and
158 those who died from any other cause, were censored. The Cox regression assumptions were tested by using
159 Schoenfeld residuals (ph-test in Stata) and also by plotting.

160
161 The 1985 questionnaire data was analyzed using non-parametric Kruskal-Wallis-test and using the Dunn-
162 Bonferroni approach for post hoc testing in pairwise comparisons for more than two groups ($p < 0.05$),
163 because some of the variables were not normally distributed and variances were not equal. The Mann-
164 Whitney-U-test was used to compare differences between sports groups and controls ($p < 0.05$).
165 Homogeneity of variances were assessed using Levene's test and normality using Kolmogorov-Smirnov's
166 test ($p < 0.05$).

167
168 P-values < 0.05 were considered statistically significant. Statistical analyses were performed using SPSS
169 statistical software (version 24.0 for Windows; SPSS Inc., Chicago, IL) and Stata 14.0 (Stata Corp, College
170 Station, Texas, USA).

171 172 **RESULTS**

173
174 The mean age of the athletes at the start of follow-up in 1970 was 45.4 years, and 44.3 years among
175 controls. Altogether, 4.0% ($n=83$) of former athletes and 6.5% ($n=94$) of controls were admitted to hospital
176 for any chronic pulmonary disease during the 45-year follow-up period. The most common reasons for
177 admissions were asthma (athletes 1.7% ($n=35$), controls 2.5% ($n=37$)) and chronic bronchitis (athletes 0.5%
178 ($n=10$), controls 1.4% ($n=20$)) (Table 2). Total days in hospital were 1693 among former athletes and 8761
179 among controls, mean of total days in hospital/total exposure years (days/years) was 3.5 (95% CI 0.2-6.9)
180 among former athletes and 7.2 (95% CI 1.7-12.7) among controls (Table 2). The median total number of
181 days in hospital was 14 (range 2-225) in all former athletes and 17 (1-6141) in controls; however, 20 former

182 athletes and 22 controls died of chronic pulmonary disease without being hospitalized at least once (Table
183 2). The mean age at the first admission of any chronic pulmonary disease was 68.2 (13.7) years for the
184 former athletes and 66.9 (12.2) years for the controls (Table 2).

185
186 The age-adjusted hazard ratios (HRs) for incidence of overall hospitalization or death due to chronic
187 pulmonary disease in former athletes was 0.61 (95% CI 0.46-0.83, $p=0.001$) compared to controls (Table 3).
188 Correspondingly, age- and SES-adjusted hazard ratios (HRs) for incidence of overall hospitalization or
189 death due to chronic pulmonary disease in former athletes was 0.62 (95% CI 0.45-0.86, $p=0.004$) compared
190 to controls (Table 3). However, no statistically significant differences were observed between former
191 athletes and controls in the analysis of different main diagnosis groups separately (Table 3).

192
193 In an additional analysis by sports category, compared to controls statistically significant age-adjusted HRs
194 were 0.54 (95% CI 0.31 - 0.96) for endurance sports athletes, 0.61 (95% CI 0.42 - 0.89) for mixed sports
195 athletes and 0.66 (95% CI 0.44 - 0.98) for power sports athletes (Table 3). Correspondingly, the age- and
196 SES-adjusted risk of chronic pulmonary diseases was higher among controls compared to endurance and
197 power sports athletes ($p<0.05$) (Table 3).

198
199 No differences in incidence were observed between those who did not respond to 1985 questionnaire study
200 and respondents, among all participants (HR=1.10, 95% CI 0.78-1.53, $p=0.60$), among former athletes
201 (HR=1.01, 95% CI 0.61-1.66, $p=0.98$) and among controls (HR=1.34, 95% CI 0.84-2.13, $p=0.21$).

203 **The 1985 questionnaire data**

204
205 Former athletes smoked less than controls ($p<0.001$). Among controls 27.8% were current smokers
206 compared with 16.1% among the former athletes, with 10.1% of endurance, 17.0% of mixed and 17.8% of
207 power sports athletes being current smokers (For more details see Table, Supplemental Digital Content 3).

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

210

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

218

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

223

224 **DISCUSSION**

225

226 There is lack of studies focused on the risk of chronic pulmonary diseases among former athletes several
227 decades after their peak sporting performance. Our study showed that the risk of any chronic pulmonary
228 disease or death was lower among former athletes than controls. Accordingly, the risk was lower among
229 endurance, mixed or power sports athletes compared to controls. Some studies have shown that the
230 prevalence of asthma is increased in elite athletes.²⁴⁻²⁵ Correspondingly, epidemiologic studies suggest that
231 self-reported and physician-diagnosed asthma are twice as common in Finnish athletes²⁶ and elite
232 Norwegian athletes²⁷ than control populations. The higher prevalence of asthma reported in athletes may be
233 a result of overdiagnosis, particularly because a diagnosis of asthma is often made on the basis of the history

234 alone.²⁸ Furthermore, respiratory symptoms may occur when exercising at high intensities which is
235 common in athletes but uncommon in non-athletes. Although if non-athletes also exercise at high
236 intensities, respiratory symptoms would probably occur more commonly. Former athletes smoked less than
237 controls, as we have also reported earlier.¹¹⁻¹³ Our findings were consistent with other studies that have
238 shown current athletes smoke less than non-athletes.⁸⁻¹⁰

239
240 This long-term follow-up study revealed new information on the long-term risk of chronic obstructive
241 pulmonary diseases morbidity and mortality among former athletes. This study extended a previous study
242 on the same cohort²⁹ which was based on questionnaire data and a nationwide reimbursable medication
243 register. The use of the valid register data covering all participants was the strength of this study, data was
244 specific but not sensitive concerning mild symptoms. Self-reported data on health-related behaviors include
245 known limitations, but the self-reported smoking status has shown to be valid and reliable reflecting the
246 social acceptance of smoking at that time.³⁶ Although questionnaire response rates were lower in individuals
247 with chronic obstructive pulmonary diseases-related hospitalizations, the risk for bias in comparing the
248 athlete group to non-athlete group was low.

249
250 Furthermore, there may have been selection bias at the beginning of our study as persons with suboptimal
251 ventilatory function as young adults may have been incapable of becoming top athletes in endurance sports,
252 thus reducing the prevalence of later chronic pulmonary disease. Furthermore, there is lack of consensus
253 whether vigorous physical activity in a cold environment, which is common in Finland for several months
254 of the year, predisposes to chronic pulmonary diseases. Some studies have found that persons who routinely
255 perform strenuous exercise in cold conditions have a high prevalence of chronic airway inflammation and
256 hyperreactivity,³⁷ also cold weather exercise can lead to asthma-like airway disease.³⁸

257
258 Because former athletes are a selected group and they competed at top-level before 1965, we do not know
259 exactly how well the results can be generalized to today's elite athletes or athletes who had competed in

260 lower level, to non-athletes or to women. Thus, we cannot conclude whether the decreased risk of
261 pulmonary disease is due to selection of persons with extraordinary lung function to start with, and hence
262 high reserve of that function in later life, or does training in adolescence and young adulthood promote
263 development of lung function, yielding greater lung health in later life. Studies have suggested that
264 interactions between genetic factors and early environmental exposures patterns may explain the early
265 development of chronic obstructive lung diseases.³⁹ Particularly genome-wide association studies (GWASs)
266 have been identifying genetic variants in the development of lung function in early life and later progression
267 to asthma and COPD, but they account for at most a modest fraction of variability in lung function. There
268 are still challenges to understand effects of genetic variants on health and disease and how they contribute
269 opportunities for therapeutic intervention.⁴⁰

271 **Conclusions**

272
273 The risk of any chronic pulmonary disease was lower among former athletes than controls even after
274 considering smoking status and cumulative smoking quantity. Former athletes were more physically active,
275 were less often smokers, had started smoking later and smoked less than controls. Furthermore, former
276 athletes reported less physician-diagnosed emphysema than controls. In conclusion, ability to compete at the
277 highest level of sports in young adulthood associates with a reduced risk of pulmonary disease in later life.

286 **Contributors**

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

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294 **Competing interest**

295 None.

296 **Ethical approval**

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

303 **Data sharing**

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

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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 (N)	Participants alive in 1970		Participants alive in 1985		Questionnaire responders in 1985		Participants alive in 2015	
		(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*	Bronchiectasia*	Any chronic pulmonary disease*	Chronic pulmonary disease-related death (no hospitalization 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.

Sports groups	N of participants with incident disease	Mean age (SD) at disease onset	Age -adjusted				Age- and SES-adjusted			
			HR	95.0% Confidence Interval		P-value*	HR	95.0% Confidence Interval		P-value*
				Lower	Upper			Lower	Upper	
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.