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All-cause and disease-specific mortality among male, former elite athletes: an average 50-year follow-up

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ABSTRACT

Aim To investigate life expectancy and mortality among former elite athletes and controls.

Methods HR analysis of cause-specific deaths sourced from the national death registry for former Finnish male endurance, team and power sports athletes (N=2363) and controls (N=1657). The median follow-up time was 50 years.

Results Median life expectancy was higher in the endurance (79.1 years, 95% CI 76.6 to 80.6) and team (78.8, 78.1 to 79.8) sports athletes than in controls (72.9, 71.8 to 74.3). Compared to controls, risk for total mortality adjusted for socioeconomic status and birth cohort was lower in the endurance ((HR 0.70, 95% CI 0.61 to 0.79)) and team (0.80, 0.72 to 0.89) sports athletes, and slightly lower in the power sports athletes (0.93, 0.85 to 1.03). HR for ischaemic heart disease mortality was lower in the endurance (0.68, 0.54 to 0.86) and team sports (0.73, 0.60 to 0.89) athletes. HR for stroke mortality was 0.52 (0.33 to 0.83) in the endurance and 0.59 (0.40 to 0.88) in the team sports athletes. Compared to controls, the risk for smoking-related cancer mortality was lower in the endurance (HR 0.20, 0.08 to 0.47) and power sports (0.40, 0.25 to 0.66) athletes. For dementia mortality, the power sports athletes, particularly boxers, had increased risk (HR 4.20, 2.30 to 7.81).

Conclusions Elite athletes have 5–6 years additional life expectancy when compared to men who were healthy as young adults. Lower mortality for cardiovascular disease was in part due to lower rates of smoking, as tobacco-related cancer mortality was especially low.

BACKGROUND

Observational studies indicate that regular physical activity is associated with a lower risk for all-cause mortality.[1] That evidence is primarily based on studies which have investigated the relationship between aerobic leisure-time physical activity and all-cause mortality.[2] Samitz *et al*[1] reported that the increase in death risk reduction per unit of time was largest for vigorous exercise.

Long-term vigorous exercise training is associated with increased survival rates in specific groups of athletes.[3] However, the association between participation in some sports, such as power sports, and mortality and longevity remains unclear. Recently, Clarke *et al*[4] investigated the 'survival of the fittest' theory and found that Olympic medallists live longer than the general population. Mortality among athletes has usually been compared to that in the general population, and thus lack of a proper healthy baseline reference group is a common limitation in these studies.

Former Finnish elite endurance athletes had a lower risk for type 2 diabetes and coronary heart disease than controls.[5] In the same cohort, also studied in this paper, two previous papers[6 7] have reported mortality among the former athletes, but based on a shorter follow-up time. By the end of the year 2011, two-thirds of the cohort members had died, which, together with the longer follow-up time and higher number of events, allowed us to improve the accuracy and statistical power of the mortality and longevity estimations and also extend the disease-specific and sports-specific mortality analysis. Therefore, we updated our analysis to examine all-cause and disease-specific mortality among former male elite endurance, team and power sports athletes and controls.

METHODS

Subjects

Our study design and population has been detailed previously.[6] In brief, for the former Finnish athlete cohort, we identified male athletes who had represented Finland between the years 1920 and 1965 at least once in international or inter-country competitions. The following sports were selected: track and field athletics, cross-country skiing, soccer, ice hockey, basketball, boxing, wrestling, weightlifting and shooting. A total of 2675 athletes fulfilled the inclusion criteria, and the full name, place and date of birth were traced for 2613 (97.7%) men. Controls (N=1712) were selected from Finnish men who were classified as healthy (military class A1, fully fit for ordinary military service) at 20 years of age at the medical examination preceding their conscription.[6] The controls were selected from public archives of the register of men liable for military service and matched for birth cohort and area of residence with the athletes.[6] This procedure was carried out in 1978–1979, when 85.5% of athletes were identified, after which no more controls were included.

For the present study, we identified from the original study cohort all the endurance (aerobic) (n=437), team (mixed) (n=1046) and power (anaerobic) (n=941) sports athletes (table 1). The classification was based on the ranking of sports by the average maximal oxygen uptake for male athletes in the Swedish national team.[8] The groups consisted of: (1) endurance sports (cross country skiing, middle-distance runners, and long distance

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Table 1 Group sizes, birth year, ages at entry, missing data and proportion of deceased in December 2011

Sports	Group size	Mean birth year	Mean age at entry	Data missing (%)	Deceased in wars*(%)	Proportion deceased (%) by December 2011
Endurance sports	437	1917.3	26.9	0.0	3.2	74.8
Long-distance running	199	1916.7	27.9	0.0	2.0	74.4
Cross-country skiing	142	1915.2	27.6	0.0	3.5	81.0
Middle-distance running	96	1921.8	24.0	0.0	5.2	66.7
Team sports	1046	1924.4	22.7	1.1	3.5	60.3
Soccer	309	1920.9	22.3	2.3	3.2	65.7
Ice hockey	168	1930.2	21.9	1.2	3.6	47.6
Basketball	92	1934.2	21.3	0.0	4.3	43.5
Other track and field†	477	1922.7	23.4	0.6	3.6	64.6
Power sports	941	1920.2	24.6	3.0	1.9	73.1
Boxing	302	1921.6	22.4	5.6	2.0	73.8
Wrestling	324	1917.1	25.9	2.2	2.8	73.8
Weightlifting	122	1925.0	25.4	3.3	0.0	73.0
Track and field throwing	193	1920.4	25.3	0.0	1.6	71.0
Controls	1712	1922.8	20.1	2.9	3.6	70.5

*Participants who were deceased in combat during Finland's wars of World War II.
†Jumpers, short-distance runners and hurdlers.

running), (2) team (mixed) sports (soccer, basketball and ice hockey, jumpers, short-distance runners and hurdlers) and (3) power sports (boxing, wrestling, weightlifting and throwing sports).

Mortality follow-up and statistical analysis

Mortality follow-up started from the time when the athlete fulfilled the inclusion criterion, that is, was an elite athlete, while controls were followed from the date of their conscription examination. Thus, the date of entry into the analysis varied and was unique for each individual. The data consisted of mortality events until 31 December 2011. Copies of death certificates for the year 1936 were obtained, with permission, from the files of Cause-of-Death Bureau at Statistics Finland. Causes of death were registered and coded according to the International Classification of Diseases (ICD) (8th version for 1969–1986: codes 1–779, the 9th version for 1987–1995: codes 1–779, the 10th version for 1996-: codes A-R, S-Y). Conversion from earlier ICD versions (1936–1968) to ICD-8–ICD-10 codes was done by Statistics Finland.

The outcome variables were total mortality, that is, death for any reason, natural and non-natural mortality, and disease-specific mortality. Disease-specific mortality included ischaemic heart disease (IHD) mortality, stroke mortality, cancer mortality, smoking-related cancer mortality, dementia mortality and alcohol-related mortality.

When calculating natural causes mortality (ICD-8 codes 000–796, ICD-9 codes 000–799, ICD-10 codes AOO-R99), mortality from external cases, including injury, suicide and homicide, was excluded.

As the socioeconomic status of the athletes and controls differed significantly,[6] we adjusted our results for socioeconomic status. Occupational data were collected partly from the Population Register Centre and partly from a questionnaire in 1985, which was mailed to the survivors of the cohort. Socioeconomic status was classified on the basis of occupational data into the following main categories: executives, clerical workers, skilled workers, unskilled workers and farmers. Each person was classified according to the occupation he had practised for the longest period. Since survival varies between birth cohorts, we adjusted the results for birth cohort, calculated in decade intervals.

The descriptive data are shown as means or proportions. Life expectancy, calculated by the Kaplan-Meier method for the different sports groups and controls, were expressed as medians and their 95% confidence intervals (CI). Non-adjusted, birth cohort or/and socioeconomic status HRs adjusted for mortality were analysed by Cox proportional hazard models separately for the different sports groups and controls. When calculating HRs and estimating life expectancy, participants who were deceased in combat during Finland's wars during World War II (see table 1) were accounted for by placing them in the 'lost' category in the analyses. Statistical analyses were performed using SPSS statistical software (V.19.0 for Windows; SPSS Inc., Chicago, Illinois, USA), and Stata V.12.1 (StataCorp, College Station, Texas, USA).

RESULTS

A total of 117 men were lost to follow-up due mainly to missing or uncertain information on date of birth or date of death. Thus, the final sample size for analysis included 4019 men. Mean age at inclusion was 23.1 years, and median follow-up time was 50 years (from 0.1 to 80 years), yielding a total of 187 621 person-years. Study group characteristics are shown in table 1. During the total follow-up period 2833 deaths occurred; 67.1% of the athletes and 70.5% of the controls died. Natural causes accounted for death in 2293 participants (80.3%).

Median life expectancy among the former endurance (79.1 years, 95% CI 76.6 to 80.6) and team sports (78.8 years, 95% CI 78.1 to 79.8) athletes was higher than among controls (72.9 years, 95% CI 71.8 to 74.3). There was also a tendency for higher life expectancy among the power sports athletes compared to controls (75.6 years, 95% CI 74.0 to 76.5). Figure 1 shows the unadjusted survival curves of the former endurance, team sports and power sports athletes and controls.

On the basis of the Cox regression models, HRs unadjusted and adjusted for socioeconomic status and birth cohort for all-cause mortality among the endurance and team sports athletes differed significantly from those for controls (table 2). When

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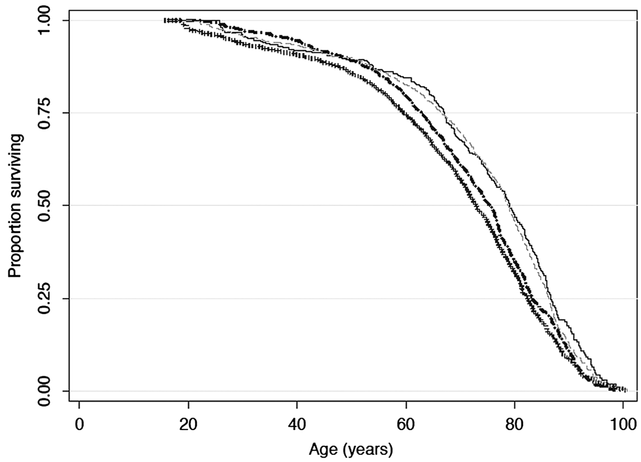

Figure 1 Survival curves of endurance sports (continuous line), team sports (grey dashed line) and power sports (black dot-dash line) athletes and controls (dotted black line). All-cause mortality follow-up until 31 December 2011 of Finnish elite male athletes representing Finland between1920 and 1965 and controls.

evaluating natural cause mortality, the covariate-adjusted HRs were lower in all the sports groups compared to controls: 0.62 (0.54 to 0.72) in the endurance, 0.71 (0.63 to 0.80) in the team sports, and 0.85 (0.77 to 0.95) in the power sports athletes. In contrast, the corresponding risk for non-natural cause mortality was at a similar level among the endurance (HR 1.02, 0.67 to 1.56) and team sports athletes (1.00, 0.72 to 1.40), but slightly higher in the power sports athletes (1.36, 1.01 to 1.85). During the follow-up period, homicide was the cause of death for seven (0.3%) participants of whom four were power sports athletes. Suicide was the cause of death for 2.9% (n=18) of the power sports, 2.0% (n=13) of the team sports, and 1.7% (n=4) of the endurance athletes. For controls, the corresponding proportion was 2.2% (n=24).

The most common specific cause of death was IHD, which occurred in 815 participants (479 athletes, 336 controls). Stroke was the cause of death in 207 participants (114 athletes, 93 controls). The specific HRs for these events among the endurance and team sports athletes differed significantly from the control value (table 3).

Of all participants, 578 (324 athletes, 254 controls) died due to cancer (table 3). Among the athletes, 17.0% and among the controls, 32.3% of the cancer deaths were smoking-related (n=137). The adjusted HRs for smoking-related cancer among the endurance (0.20, 0.08 to 0.47) and power sports athletes (0.40, 0.25 to 0.66) differed significantly from the control value, whereas among the team sports athletes only a tendency towards a lower risk was observed (0.66, 0.41 to 1.04).

Sixty-five participants' deaths were alcohol-related. In these cases, the risk among the former endurance athletes (HR 0.84, 0.32 to 2.27) did not differ from the control value, although a tendency to a slightly elevated risk was found among the team (1.50, 0.77 to 2.91) and power sports athletes (1.55, 0.82 to 2.91).

Dementia was the cause of death in 102 participants. Among this group, the power sports athletes appear to be at higher risk (table 3). To investigate the reason for this finding, we conducted a sports-specific analysis and found that dementia mortality was significantly higher in former boxers. Eighteen of the 36 dementia mortality cases among the power athletes were specifically among boxers, whose HR was 4.20 (2.30 to 7.81), when compared to controls.

DISCUSSION

We investigated the role of long-term vigorous physical activity on total and disease-specific mortality and life expectancy in the former male elite endurance, team sports and power sports athletes as well as in controls. Our findings showed that the former elite athletes survived 5–6 years longer than controls who had been classified as healthy at the age of 20 years.

Comparison with other studies

Total mortality and most of the disease-specific mortality ratios were lower in the endurance and team sports athletes compared to controls. Our results extend previous findings[3] that the endurance and mixed sports athletes have lower mortality and higher longevity than the general population. Previous studies have reported inconsistent results for power sports athletes.[4] During the 50-year follow-up, 73% of our power sports athletes died, showing a mortality risk slightly lower than that of the control participants. Furthermore, the median life expectancy of the power sports athletes was almost 3 years higher than that of controls. As more than half of all participants in all the sports groups had died, our median life expectancies are true and not estimated life expectancies.

Interpretation of findings

There was a tendency towards a higher number of homicide-related and suicide-related deaths in the power sports athletes. Lindqvist *et al*,[9] in a recent study on power sports athletes, reported an increased risk for premature death by suicide among powerlifters suspected of using anabolic agents.[10] Our former elite athletes primarily competed between 1920 and

Table 2 Number of participants, time at risk, number of deaths and all-cause mortality HRs and their 95% CI's in different sport groups compared to controls

Sports	N	Time at risk; median, years	Number of deaths	HR† (95% CI)	HR‡ (95% CI)	HR§ (95% CI)	HR¶ (95% CI)
Endurance sports	437	49.1	326	0.70 (0.62 to 0.79)*	0.75 (0.66 to 0.85)*	0.65 (0.58 to 0.74)*	0.70 (0.61 to 0.79)*
Team sports	1027	50.3	629	0.72 (0.65 to 0.79)*	0.80 (0.72 to 0.89)*	0.73 (0.67 to 0.81)*	0.80 (0.72 to 0.89)*
Power sports	899	47.8	676	0.93 (0.84 to 1.02)	0.98 (0.89 to 1.08)	0.89 (0.81 to 0.98)*	0.93 (0.85 to 1.03)
Controls	1657	49.9	1202	1	1	1	1

*p<0.05.
†Non-adjusted HR.
‡Adjusted for socioeconomic status.
§Adjusted for birth cohort.
¶Adjusted for socioeconomic status and birth cohort.

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Table 3 Disease-specific mortality HRs and their 95% CI in different sport groups compared to controls

	Mortality HR† (95% CI)			
Sports	**Ischaemic heart disease (n=815)**	**Cancer (n=578)**	**Stroke (n=207)**	**Dementia (n=102)**
Endurance sports	0.68 (0.54 to 0.86)*	0.62 (0.47 to 0.82)*	0.52 (0.33 to 0.83)*	1.05 (0.54 to 2.04)
Team sports	0.73 (0.60 to 0.89)*	0.72 (0.58 to 0.90)*	0.59 (0.40 to 0.88)*	1.17 (0.65 to 2.10)
Power sports	0.99 (0.83 to 1.18)	0.80 (0.64 to 1.00)	0.73 (0.51 to 1.05)	2.08 (1.24 to 3.51)*
Controls	1	1	1	1

*p<0.05.
†Adjusted for socioeconomic status and birth cohort.

1965 when use of anabolic agents in Finland was rare.[11] The higher risk for non-natural causes of death among the power sports athletes may partly be explained by personality characteristics. Bäckmand *et al*,[12] who investigated personality characteristics among our cohort members, found that the combat sports athletes scored highest on a neuroticism scale, and that life satisfaction was lower among individual power sports athletes compared to the other athletes. We do, however, not have an explanation for the higher tendency to suicide among power sports athletes. Our power sports athletes died from suicide at the mean age of 58.2 years, that is, after their active athletic career. In a recent review, Iverson[13] evaluated the relationship between chronic traumatic encephalopathy (CTE) and suicide in former athletes. He concluded that there is insufficient evidence to support the causal connection between CTE and suicide in former athletes. Overall, the phenomenon of CTE remains controversial.[14 15]

Participation in long-term vigorous physical activity appears to postpone, but does not fully prevent death from IHD. IHD is the most common cause of death in athletes and controls. Kujala *et al*[16] investigated the prevalence of IHD in 1985 among survivors of the same cohort, when the mean age of the athlete groups and controls varied between 55 and 61 years. The age-adjusted risk for IHD was clearly lower in athletes than in controls. However, at the end of the present follow-up, the relative number of deaths from IHD in athletes and controls was at the same level (18.6% vs 19.3%). This trend was particularly evident in the endurance athletes, of whom 20.4% had died from IHD at a mean age of 72.4 years. The corresponding age in controls was 67.4 years.

In their review, Reimers *et al*[17] evaluated the results of 33 prospective cohort studies and 10 case–control studies that addressed the potential effect of physical activity on stroke-related morbidity and mortality. The authors concluded that, in men, regular physical activity reduced the risk of suffering an ischaemic stroke or dying from one by 27% and the risk of a cerebral haemorrhage by 40%. The risk for death from stroke was lower in the endurance and team sports athletes than in controls. The mean age of death from stroke was 78 years in the endurance athletes, 77.6 years in the team sports athletes, 72.8 years in the power sports athletes and 68.9 in controls. As with IHD, participation in long-term vigorous physical activity appears to postpone death from stroke in the endurance and team sports athletes.

Certain lifestyle habits, such as physical inactivity, smoking and excessive alcohol intake, are major determinants for preventable morbidity and mortality. Former athletes differ from the general population in their level of physical activity and other health-related behaviours.[6 18 19] For instance, health habits, such as smoking and diet, are differently distributed between athletes and the general population.[6 18] According to previous studies, athletes smoke less than controls.[6 18] Pukkala *et al*[20] calculated the cancer incidence of our athlete cohort based on the data of the Finnish Cancer Registry during 1967–1995. They found that athletes had a reduced risk for smoking-related cancers, but that the risk for other cancers was not below that of the general population. After adjustment for smoking, no difference in cancer risk was found. Their findings are in line with our results.

Alcohol-related causes as a primary reason for death were rare (2.3%) in our cohort, which is consistent with the underreporting of addiction-related causes in cause of death data. Unexpectedly, both team sports and power sports athletes had a tendency towards increased risk for alcohol-related deaths. However, the low number of such cases means we need to limit our conclusions.

Whether traumatic brain injury (TBI) is a risk factor for dementia is a hot topic.[21] Smith *et al* concluded that according to current autopsy studies, survival from repetitive mild or even single moderate to severe TBI is associated with a range of pathologies. The authors also hypothesised that one single injury or repetitive TBI may lead to early-onset clinical symptoms. We investigated the disease-specific cause of death from dementia, and found that while our boxers were at increased risk for death from dementia, their mean age at death from that disease was 81.3 years compared to 79.8 years in controls.

Study strengths and weaknesses

The present study has several strengths. A long follow-up time with a high number of events gave us the possibility to calculate the true median life expectancy. Moreover, the cause-of-death data with a low number of missing causes allowed us to analyse disease-specific and sport-specific mortalities without risk of major selection bias. As controls, we used men who, on the basis of a medical examination as young adults, were classified as healthy and fully fit for ordinary military service. This control group compares more favourably with athletes than the general population at large, which includes individuals with chronic diseases at a young age.

The aim of the study was to compare all-cause and disease-specific mortality between the former male elite athletes and population-sample controls. The possible selection and lack of data on some confounding and modifying factors do not permit calculation of the role of long-term physical activity separately for mortality and life expectancy. Furthermore, most of our participants were amateur athletes whose sporting careers would have differed in many respects from the present-day situation. Therefore, the results cannot be generalised to today's athletes. The long-term effects of the demanding training and competition period on the health of today's athlete's health remains to be investigated in the future.

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CONCLUSION

On the basis of the 1985 questionnaire data, about 60% of former elite athletes had retained an active and sports-centred lifestyle throughout their adulthood, as compared to only 17% of controls.[22] Besides lifestyle factors, selection bias may also explain the reduction in premature mortality among former male athletes, given the multiple hurdles that have to be overcome to embark on an athletic career and go on to succeed at the highest level of performance. Overall, former male athletes can be expected to live longer than the population at large.

What is already known on this topic?

Regular physical activity is associated with a lower risk for all-cause mortality, but knowledge on the impact of different types of vigorous physical activity on all-cause, and especially disease-specific, mortality is limited.

What are the new findings?

- Participation in long-term vigorous physical activity appears to postpone death owing to the lower risk for diseases such as ischaemic heart disease and stroke.
- Athletes, who typically need a good aerobic fitness level, appeared to maintain a healthy lifestyle, resulting in 5–6 years additional life expectancy compared to men who were healthy as young adults.

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Contributors JAK contributed to the study design and analyses, wrote the first version of the manuscript with HB, and also drafted and revised the manuscript. UMK, JK, MP, JGE and SS contributed to the study design and analyses, and revised the manuscript. SS collected the original cohort data. JAK is responsible for the overall content as guarantor. All authors participated in the collection of the follow-up data, and have approved the final manuscript.

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