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Lifetime physical activity and cancer incidence—A cohort study of male former elite athletes in Finland

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ABSTRACT

Objectives: Physical activity has been shown to decrease the risk of certain cancers. Objective of this study was to assess the effect of physical activity on cancer incidence in former male athletes in older age.
Design: A cohort of 2448 elite male athletes and 1712 referents was followed-up for cancer incidence during 1986–2010 through the Finnish Cancer Registry.
Methods: Standardised incidence ratios were calculated with the general male population as the reference. Self-reported questionnaire-based data on covariates were used in Cox regression analyses comparing the risk of cancer in athletes and referents.
Results: The overall cancer incidence was lower in athletes than in the general population, standardised incidence ratio 0.89 (95% confidence interval 0.81–0.97). It was lowest among middle-distance runners (standardised incidence ratio 0.51, 95% confidence interval 0.22–1.01), long-distance runners (standardised incidence ratio 0.57, 95% confidence interval 0.35–0.88) and jumpers (standardised incidence ratio 0.60, 95% confidence interval 0.37–0.92). The standardised incidence ratio of lung cancer among athletes was 0.40 (95% confidence interval 0.27–0.55) and that of kidney cancer 0.23 (95% confidence interval 0.06–0.57). The hazard ratio for lung cancer between athletes and referents increased from the unadjusted ratio of 0.29 (95% confidence interval: 0.18–0.48) to 0.61 (95% confidence interval: 0.30–1.26) after adjustment for smoking status and pack-years of smoking.
Conclusions: Former male elite athletes evidently have less cancer than men on the average. The lesser risk can be attributed to lifestyle factors, notably less frequent smoking among the athletes.

1. Introduction

In addition to the well-recognized role of smoking, alcohol consumption and unhealthy diet in the aetiology of many cancers, increasing evidence implicates physical inactivity as a risk factor for some cancers. In 2002 the International Agency for Research on Cancer (IARC) estimated that excess body weight and physical inactivity could account for one quarter to one third of cancers of colon, kidney and oesophagus.[1] Since especially leisure-time physical activity is usually associated with a generally healthier lifestyle,[2,3] the independent role of physical activity in the aetiology of cancer may be difficult to demonstrate.

Several studies have reported links between physical activity and reduced risk of certain cancers, especially breast[4,5] and colon cancer.[6–8] There is conflicting evidence from the studies on prostate, lung and kidney cancer among physically active men. Some studies have suggested that the risks of these cancers are lower among the more physically active[9,10] but not all studies agree with this finding.[11,12]

Cancer incidence of Finnish world-class athletes in 1967–1995 was reported to be one-fifth lower than that of the general Finnish male population.[13] This was mainly explained by smaller incidence

Abbreviations: BMI, body mass index; CI, confidence interval; HR, hazard ratio; IARC, International Agency for Research on Cancer; LTPA, leisure-time physical activity; MET, standard metabolic equivalent; PIC, personal identity code; SES, socio-economic status; SIR, standardised incidence ratio.

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of smoking-related cancers in the athletes, but individual-level risk factor data prior to 1985 were not available. The value of studying elite athletes is that there is a documented period of intensive physical activity needed to achieve elite status and this information is available historically obviating the need to study young adults prospectively into the period of high risk for cancer decades later. However, elite athletes differ also for other cancer risk factors, which need to be accounted for in a rigorous analysis of the relationship of elite athlete status with future cancer. We now report the cancer incidence of these individuals for a period of 21 years from 1986 to 2010, with due consideration of cancer-related life-style factors collected in 1985.

The aim of this study was to evaluate the effects of an athlete status and their lifestyle covariates in incidence of different cancers.

2. Methods

The study cohort consisted of Finnish male athletes, who had represented Finland between the years 1920 and 1965 at least once in international or inter-country competitions (for details, see Sarna et al.[14]). The following sports were selected: track and field athletics, cross-country skiing, soccer, ice hockey, basketball, boxing, wrestling, weight lifting, and shooting. Sport disciplines were chosen based on the numbers of Finnish Olympic games participants. In addition it was made sure that endurance, speed, power and team sports disciplines were included in the cohort. One referent for each athlete was selected from the archives of the registry of men liable for military service, matched for year of birth and area of residence. The referent had to have been classified as completely healthy ("A1 category") at the compulsory medical examination for induction into military service at age of 20 years (referents were born between years 1898 and 1948). No eligible referent was traced for 15% of athletes because ice hockey, basketball, weight lifting, and shooting were retrospectively included in the study after selection of the referents.

The original study cohort consisted of 2448 athletes and 1712 referents. In 1985 a questionnaire on physical activity and health was mailed to the survivors of the cohort and their referents. The response proportion was 85% for the athletes and 81% for the referents. We had no reason to expect recall bias between the two groups. Out of the responders 1324 athletes and 754 of referents had no missing values on the main covariates. All persons with non-missing values of variables included in the models were included in the Cox regression analyses.

Everyone residing in Finland since 1967 has been assigned a unique personal identity code (PIC), which is used in all main registers. PICs for every cohort member together with possible dates of emigration or death were obtained from the Population Register Centre of Finland. Follow-up for cancer through the files of the population-based countrywide Finnish Cancer Registry was done using the PIC as a key.

In this article we report the cancer incidence of the survivors of the cohort on the 1st of January 1986 from 1st of January 1986 to death or 31st of December 2010.

The ethics committee of the University of Helsinki approved the study, and all subjects have provided informed consent.

Assessment of leisure-time physical activity (LTPA) was based on three structured questions on participation in recreational physical activity. The activity-MET index was used as a measure of physical activity level in 1985 and expressed as the score of MET-hours per week. It was further classified into five groups by four quintiles (lowest quintile value 3 and highest 45 MET-hours per week) (Table 1). For Cox regression analyses the three middle fifths (II–IV) were combined. Athletes exercised more MET-hours weekly than their referents (Table 1).

Table 1
Distribution of the background characteristics of the study subjects on December 31, 1985.

Characteristic	Athletes	Referents
Age	N = 1609	N = 1046
Years: median (min–max)	55.2 (35.6–93.8)	53.3 (38.0–87.5)
≤50 years	31.1%	36.3%
50–64 years	45.9%	45.5%
65–79 years	20.3%	16.5%
≥80 years	2.7%	1.6%
Leisure time physical activity (LTPA)	N = 1257	N = 731
MET[a], MET * h/week: median (min–max)	18 (0–228)	6 (0–228)
Lowest fifth (<3 MET * h/week)	13.6%	32.6%
Intermediate (fifth II, III & IV (3–45 MET * h/week)	65.9%	60.5%
Highest fifth V (>45 MET * h/week)	20.5%	7.0%
Alcohol consumption	N = 1238	N = 723
Abstainers (<1 drinks/week)	11.7%	15.5%
Occasional users (1–3 drinks/week)	45.4%	46.7%
Moderate users (3–14 drinks/week)	29.7%	25.4%
Heavy users (≥14 drinks/week)	13.2%	12.3%
Cigarette smoking status	N = 1247	N = 725
Never smokers	48.9%	28.0%
Occasional smokers	4.7%	2.5%
Ex-smokers	30.6%	40.7%
Current smokers	15.9%	28.8%
Pack-years for current smokers: median, during smoking period (min–max)	15 (0.4–87)	23 (0.4–72)
Body mass index (BMI)	N = 1264	N = 735
kg/m^2: median (min–max)	25.6 (16.2–43.3)	26.1 (15.8–58.1)
Normal weight (BMI ≤ 24.99)	41.8%	36.5%
Overweight (BMI 25.00–29.99)	46.4%	50.9%
Obese (BMI ≥ 30.00)	11.9%	12.7%
Socio-economic status	N = 1579	N = 962
Executives	26.4%	10.3%
Clerical workers	40.5%	23.4%
Skilled workers	26.5%	41.6%
Unskilled workers	2.1%	7.9%
Agricultural workers	4.3%	16.5%
Other	0.3%	0.3%

[a] The metabolic equivalent (MET) index was calculated by assigning a coefficient of the resting metabolic rate to each activity and by calculating the product of intensity × duration × frequency.

Alcohol consumption was evaluated by quantity-frequency measures of beverages. Respondents were categorised as abstainers, light, moderate and heavy users of alcohol based on number of drinks per week.[15]

Smoking status was based on a detailed smoking history.[16] Respondents were classified into four categories: never, ex-, occasional or current (daily or almost daily) smokers. Current smokers were defined as persons, who had smoked more than 100 cigarettes in their lifetime and smoked daily or almost daily at the time of the 1985 questionnaire. For Cox regression analyses the groups occasional and current smokers were combined.

Duration of smoking was based on age of onset of smoking and age in 1985 (for current smokers), or age at cessation (for former smokers). In the calculation of pack-years of smoking for current smokers in 1985, the daily smoking was classified as follows: those who smoked 1–15 cigarettes daily were given value of 0.4 packs (8 cigarettes/day); for those who smoked more than 15, but less than 25 cigarettes/day were given a value of 1.0 pack; and for those who smoked >25 cigarettes/day were given a value of 1.5 packs. The numbers of pack-years was then packs smoked daily multiplied by the number of years of smoking.

Self-reported data on height (m) and weight (kg) were used to calculate the body mass index (BMI) as weight divided by height squared (kg/m^2).

Table 2
Observed (Obs) and expected (Exp) numbers of cancer cases, and standardised incidence ratios (SIR) with 95% confidence intervals (CI) for most common and all smoking related cancers among the athletes and referents.

Cancer site	Athletes			Referents		
	Obs	Exp	SIR (95%CI)	Obs	Exp	SIR (95%CI)
All sites	452	509.8	0.89 (0.81–0.97)	289	281.0	1.03 (0.91–1.15)
Strongly smoking-related cancers	109	163.8	0.67 (0.55–0.80)	93	91.1	1.02 (0.82–1.25)
Lung	33	82.9	0.40 (0.27–0.55)	54	46.1	1.17 (0.88–1.52)
Other	76	80.9	0.94 (0.74–1.17)	33	37.2	0.89 (0.61–1.24)
Larynx	4	4.5	0.89 (0.24–2.27)	3	2.6	1.14 (0.24–3.33)
Oral cavity and tongue	4	1.7	2.40 (0.65–6.14)	0	1.0	0.00 (0.00–3.71)
Pharynx	2	1.9	1.07 (0.13–3.86)	1	1.1	0.89 (0.02–4.96)
Oesophagus	5	5.9	0.85 (0.28–1.98)	3	3.3	0.91 (0.19–2.65)
Pancreas	17	17.8	0.95 (0.55–1.52)	10	9.9	1.01 (0.49–1.86)
Kidney, renal pelvis	4	17.7	0.23 (0.06–0.57)	7	10.2	0.69 (0.28–1.42)
Urinary bladder	40	29.3	1.36 (0.97–1.85)	15	15.7	0.95 (0.53–1.57)
Weakly smoking-related cancers	39	46.9	0.83 (0.59–1.14)	23	25.4	0.91 (0.57–1.36)
Lip	1	4.7	0.21 (0.01–1.19)	0	2.5	0.00 (0.00–1.46)
Liver	7	8.5	0.82 (0.33–1.69)	4	4.7	0.85 (0.23–2.18))
Stomach	16	22.0	0.73 (0.42–1.18)	12	11.8	1.02 (0.53–1.77)
Leukaemia	14	10.9	1.29 (0.70–2.16)	5	5.9	0.84 (0.27–1.97)
Alcohol-related cancers (all also related to smoking)	22	24.6	0.91 (0.57–1.37)	9	11.0	0.82 (0.37–1.54)
Other						
Rectum, rectosigmoid, anus	20	20.7	0.97 (0.59–1.49)	10	11.6	0.87 (0.42–1.59)
Colon	24	27.2	0.88 (0.57–1.31)	16	14.9	1.08 (0.62–1.74)
Prostate	159	152.6	1.04 (0.89–1.21)	84	83.7	1.00 (0.80–1.24)
Skin melanoma	8	11.8	0.68 (0.29–1.33)	11	6.9	1.60 (0.80–2.85)
Skin, non-melanoma	25	21.8	1.15 (0.74–1.69)	11	11.0	1.00 (0.50–1.78)
Brain and central nervous system	13	9.1	1.43 (0.76–2.44)	4	5.4	0.74 (0.20–1.90)
Non-Hodgkin-lymphoma	15	16.7	0.90 (0.50–1.48)	13	9.5	1.37 (0.73–2.34)
Multiple myeloma	7	6.7	1.05 (0.42–2.15)	5	3.7	1.37 (0.45–3.19)
Not included above						
Skin, basal cell cancer	126	106.5	1.18 (0.99–1.39)	55	58.2	0.94 (0.71–1.22)

The socioeconomic status was based on data on subject's occupation collected partly from the Central Population Register of Finland and partly from the questionnaire of year 1985. A much larger proportion of athletes than referents belonged to the highest socio-economic categories (Table 1).

Person-years at risk during 1986–2010 were counted by five-year age groups and by five-year calendar time periods. The expected number of cancer cases was calculated by multiplying the number of person-years in each stratum by the corresponding cancer incidence rate in the overall Finnish male population. The standardised incidence ratio (SIR) was calculated as the ratio of the observed to the expected number of cases. The 95% confidence intervals (CI) were obtained assuming a Poisson distribution of the number of cases.

Finnish Cancer Registry includes accurate information of more than 99% of cancers diagnosed in Finland since 1953.[17] All cancer cases that were reported to Finnish cancer registry were included in the analyses. Smoking-related cancers were analysed in three groups: (i) lung cancer; (ii) other cancers that have a strong confirmed association with smoking (cancers of the larynx, upper digestive track, oral cavity and tongue, pharynx, pancreas, urinary tract, kidney and urinary bladder); and (iii) cancers that have a weak association with smoking (cancers of the lip, liver and stomach, and leukaemia).[18]

Cox regression analyses[19] comparing the risk of cancer in athletes vs. referents after adjustment for other factors were performed for lung cancer, all other smoking-related cancers, prostate cancer and colon cancer. Adjustment for age in each analysis was made by using age as the time scale in the Cox models. The smoking status (current smokers, former/unknown smoking status and others), pack-years of smoking, BMI, alcohol use, reported physical exercise in 1985 and socioeconomic status were also included in the regression analyses as potential confounders or covariates. The results of Cox regression analyses are reported as hazard ratios (HR). The assumptions of the Cox model were tested for proportionality. All Cox regression calculations were performed with Stata software, release 10 (Stata Corp., College Station, TX, USA).

3. Results

Athletes were somewhat older than their referents, their median age was 55 years when the median age of the referents was 53 years. Athletes also engaged more in leisure time physical activity (LTPA) – one fifth of the athletes exercised more than 45 MET * h/week, when only 7% of the referents did so (Table 1).

The athletes used a bit more alcohol (median 6.9 g/day) than their referents (median 6.3 g/day). Current smoking was less common among athletes (16%) than among referents (29%) in 1985. The median number of pack-years for smoking athletes was 15 and for referents who smoked 23. The athletes were also somewhat leaner than referents (Table 1).

The overall cancer incidence for athletes was lower than in the general population (SIR 0.89, 95%CI 0.81–0.97) (Table 2). We noticed a significant reduction for two smoking related cancers: the SIR for lung cancer was 0.40 (95%CI 0.27–0.55) and for renal cancer 0.23 (95%CI 0.06–0.57).

The overall cancer incidence was lowest for middle-distance runners (SIR 0.51, 95%CI 0.22–1.01), long-distance runners (SIR 0.57, 95%CI 0.35–0.86) and jumpers (SIR 0.60, 95%CI 0.37–0.92). The athlete group specific SIRs for all cancer types with expected number of cases ≥5 in any group are reported in the Appendix Table.

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The SIR for all cancers combined among the referents was 1.03 (95%CI 0.91–1.15). None of the site-specific differences between the observed and expected numbers among the referents were statistically significant (Table 2).

The Cox regression analysis showed an age-adjusted HR of 0.92 (95%CI 0.79–1.07) for overall cancer between the athletes and referents (Table 3). Adjustment for smoking status, pack-years of

Table 3
Hazard ratios of selected cancers for athletes compared with referents derived from Cox regression analyses. The alternative models include smoking status (no/ex/current), pack-years of smoking for current smokers, leisure-time physical activity (LTPA as metabolic equivalent index, MET) and socioeconomic status (SES) reported in 1985.

Cancer variables in the model	Hazard ratio (95% confidence interval)
All cancer sites	
None	0.92 (0.79–1.07)
Smoking status	0.92 (0.80–1.20)
Smoking status + pack-years + LTPA	0.99 (0.81–1.21)
LTPA	0.93 (0.80–1.09)
Socioeconomic status	0.86 (0.73–1.01)
Socioeconomic status + smoking status + pack-years + LTPA	0.97 (0.79–1.20)
Lung cancer	
None	0.29 (0.18–0.48)
Smoking status	0.39 (0.24–0.64)
Smoking status + pack-years	0.61 (0.30–1.26)
Smoking status + pack-years + LTPA	0.59 (0.29–1.23)
LTPA	0.29 (0.18–0.47)
Socioeconomic status	0.38 (0.22–0.64)
Socioeconomic status + smoking status + pack-years + LTPA	0.89 (0.42–1.90)
Other strongly smoking related cancers[a]	
None	1.02 (0.65–1.59)
Smoking status	1.11 (0.71–1.75)
Smoking status + pack-years	0.99 (0.56–1.78)
Smoking status + pack-years + LTPA	1.00 (0.55–1.80)
LTPA	1.05 (0.67–1.65)
Socioeconomic status	0.86 (0.53–1.37)
Socioeconomic status + smoking status + pack-years + LTPA	0.87 (0.47–1.60)
Colon cancer	
None	0.70 (0.33–1.47)
Smoking status	0.78 (0.36–1.67)
Smoking status + pack-years	1.13 (0.43–2.99)
Smoking status + pack-years + LTPA	1.19 (0.45–3.18)
LTPA	0.44 (0.20–0.97)
Socioeconomic status	0.71 (0.32–1.57)
Socioeconomic status + smoking status + pack-years + LTPA	1.17 (0.43–3.24)
Prostate cancer	
None	1.03 (0.77–1.37)
Smoking status	0.95 (0.71–0.27)
Smoking status + pack-years	1.09 (0.75–1.58)
Smoking status + pack-years + LTPA	1.07 (0.74–1.56)
LTPA	0.91 (0.69–1.20)
Socioeconomic status	0.99 (0.73–1.35)
Socioeconomic status + smoking status + pack-years + LTPA	1.12 (0.76–1.65)
Renal cancer	
None	0.19 (0.04–0.96)
Smoking status	0.19 (0.04–0.97)
Smoking status + pack-years	0.13 (0.01–1.26)
Smoking status + pack-years + LTPA	0.12 (0.01–1.14)
LTPA	0.19 (0.04–0.96)
Socioeconomic status	0.23 (0.04–1.28)
Socioeconomic status + smoking status + pack-years + LTPA	0.17 (0.02–1.80)

[a] Cancer types strongly related to tobacco smoking: larynx, oral cavity and tongue, pharynx, oesophagus, pancreas, kidney and urinary bladder.

smoking and LTPA in 1985 raised the HR to 0.99, 95%CI 0.81–1.21. After adjustment for socio-economic status (SES) the HR for cancer incidence was 0.86 (95%CI 0.73–1.01).

Compared to referents athletes had less lung cancer even after the result was adjusted for smoking status (HR 0.39, 95%CI 0.24–0.64), but this was strongly attenuated after further adjustment with pack-years (HR 0.61, 95%CI 0.30–1.26) (Table 3). Lung cancer was the only cancer that remained significant between athletes and referents after adjustment for socioeconomic status (SES) alone (HR 0.38, 95%CI 0.22–0.64), but when adjusted also for smoking status, pack-years and SES, the difference disappeared (HR = 0.97, 95% CI 0.79–1.20). Other strongly smoking-related cancers showed HRs of about 1.0 for athletes, irrespective of the presence or absence of smoking variables in the model.

The hazard ratio for colon cancer of athletes in comparison to the referents was 0.70 (95%CI 0.33–1.47) in the crude model and was attenuated in the models including smoking variables. When the result was adjusted for LTPA, the protective effect was statistically significant (HR 0.44, 95%CI 0.20–0.97), but not significant in a model, which included also smoking (HR 1.19, 95% CI 0.45–3.18). Hazard ratios for prostate cancer for athletes were close to 1.0 in all models (Table 3). Adding other variables to the models did not change the results significantly.

There were only four cases of renal cancer among athletes vs. 17.7 expected. The risk factors for renal cancer include smoking, obesity and possibly hypertension[20] and/or hypertensive medication[20]. Despite the small number of cases (8) Cox regression analyses for renal cancer yielded some significant results. When adjusted for LTPA the HR was 0.19 (0.04–0.96) and when smoking was added to the model the HR stayed the same: 0.19 (0.04–0.97). Adding other variables (amount of smoking in pack-years, socioeconomic status) yielded even lower HRs but the results lost their statistical significance. Hence the cofactors seem not to give satisfactory explanation for such an extremely low incidence of renal cancer among athletes.

In addition to the results presented in Table 3, Cox regression analyses were made with SES, smoking status, pack-years, LTPA and alcohol use, but these analysis did not have any significant effect on the presented results. BMI was not included in the analyses due to the fact that BMI for athletes is elevated due to muscular build instead of body fat and does not necessarily reflect the same risks attributed to fat mass as it does in general population.[21]

4. Discussion

We observed a lower overall cancer incidence in athletes than in the general population or among the men in the reference cohort. It has also been seen in other studies that aerobic exercise protects from many cancers[1] possibly due to hormonal changes,[22] body-fat alterations[22] or shorter intestinal transit time.[23] In our study exceptionally low overall cancer incidence rates were observed among athletes with aerobic exercise, i.e., middle-distance and long-distance runners, but not in cross-country skiers. The SIRs were 0.51 (95%CI 0.22–1.01), 0.57 (95% CI 0.35–0.86), and 0.84, (95%CI 0.54–1.23), respectively. Nearly all the decrease in overall cancer incidence among the athletes is due to low incidence of lung cancer. The difference between observed and expected number of cases was about 58 cases overall, of which 50 was due to lung cancer alone. The incidence of renal cancer in athletes was also markedly lower than expected.

The incidence for lung cancer among athletes was less than half of that of both the general population and the referents. The hazard ratio rose to 0.89 (95%CI 0.42–1.90) and lost statistical significance when the amount smoked (in pack-years), LTPA and socioeconomic status were added in the model. These findings are in line with the information that the prevalence of smokers among athletes was lower than among the referents and that athlete smokers smoked less than referents who smoked. Our findings are in line with a recently published meta-analysis.[24] A similar pattern was observed for other tobacco-related cancers.

In this study a 30% non-significantly lower incidence of colon cancer was detected among the athletes when compared to their referents, and the difference totally disappeared after adjustment for covariates. It may be that intense physical activity as young adults is not the period yielding the most protection, but physical activity would need to be continued later in life (which is consistent with the low risk observed when adjusted only for later leisure-time physical activity). The small number of cases in the cohort population limits the possibilities for more extensive analyses.

The athletes and referents had exactly same prostate cancer incidence, when the result was adjusted for socio-economic status. A part of prostate cancer incidence in the Nordic countries (with the exception of Denmark) since the 1990s may be related to frequency of PSA-testing[25] but other factors cannot be excluded. A recent meta-analysis suggests that physical activity is associated with a 10% reduced risk of prostate cancer, but the risk is lower for occupational physical activity (relative risk 0.81) than for leisure-time physical activity (0.95, 95%CI 0.89–1.00). Our estimate is fully compatible with the meta-analysis.[26]

While none of the invasive cancer types showed elevated risk among the athletes, we observed a borderline non-significant 18% excess incidence of basal cell cancer of skin. The risk for other non-melanoma skin cancer was also elevated, but this excess was not statistically significant. Skin melanoma was less common in the athletes than in the average population or among the referents. The risk of non-melanoma skin cancer is elevated in professions that include exposure to ultraviolet light (work outdoors, e.g. farmers),[25,27] while outdoor workers tend to have low risk of skin melanoma.[25] Many athletes exercise and compete outdoors during their athletic careers and which might explain the similarity of their skin cancer risk pattern with that of Finnish outdoor workers.[25] It has also been observed before that physical exercise does not protect from non-melanoma skin cancer.[28] Finally, very vigorous exercise may induce immunosuppression, which is known to increase the risk of non-melanoma skin cancers.[29]

This study gives a realistic picture of cancer pattern of athletes. The cohort was comprehensively identified from a variety of sources and the Finnish registries, which enable accurate record linkage and complete long-term follow-up for the cancer incidence of this cohort, with no losses to follow-up. Unfortunately not enough women could be identified as elite athletes during the inclusion period of the present cohort and hence no results can be given on elite athlete status and cancer in women. The last athletes in the cohort were included before the increase in use of performance-enhancing doping agents, so these agents are unlikely to have marked effect on the results that we have seen.

The athletes of this cohort differ from the general population by the level of their physical activity and some other health habits: they smoke less and they are less obese than their referents.[30] This could be analysed in an unbiased way as the former athletes responded well to the 1985 questionnaire. About 60% of former elite athletes continued an active and sports-oriented lifestyle throughout their adulthood, while only less than 20% of their age-matched controls did so.[14] Physically active lifestyle is often combined with other features of a healthy lifestyle such as healthy diet and non-smoking.[13]

The referent population was recruited from "A1-classified" men at military service. Although these men were rated as completely healthy in age 20, their cancer incidence rates later in life did not differ from the rates of the entire population. Hence the reference cohort appears to represent quite well the general population and is an acceptable reference for the analyses of cancer in former elite athletes.

Our main conclusion is that former elite athlete status has – especially among endurance athletes – modified the life-long pattern of risk factors of cancer to generally positive direction. Former athletes have continued their physically active lifestyle, healthy diet and low smoking. This lifestyle has given them protection against several types of cancers up to their old ages.

5. Conclusions

Former male elite athletes evidently have less cancer than men on the average. Much of the lesser risk is due to the lifestyle factors, notably less frequent smoking among the athletes.

6. Practical implications

- Athletes have fewer cancers than general population. The incidence is lowest among those engaged in endurance sports.
- Especially notable is the difference in lung and renal cancer.
- Most, if not all, of this is due to healthy lifestyle, especially less frequent smoking.
- The healthy lifestyle may also be a consequence of the training and other requirements for being an elite athletes, hence making it difficult to attribute causal effects based on this data alone.

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