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# Adverse health behaviours in long-term testicular cancer survivors: a Danish nationwide study

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**ABSTRACT**

**Background:** Treatment for disseminated testicular cancer increases the risk of secondary malignancy and cardiovascular disease. The risk of developing these serious adverse effects may be positively affected by healthy living. The purpose of this study was to identify health behaviours with possible influence on late effects that could be targets for intervention.

**Material and methods:** In this cross-sectional study, testicular cancer survivors diagnosed in the period 1984–2007 from the Danish Testicular Cancer database completed a questionnaire on health behaviours (2014–2016). We estimated prevalence of smoking, alcohol consumption, sedentary lifestyle and overweight. Prevalence ratios described with 95% confidence intervals of adverse health behaviours were stratified by treatment modalities and compared to a reference population by means of logistic regression with adjustment for sociodemographic confounders.

**Results:** In total, 2395 testicular cancer survivors (surveillance, 1175; chemotherapy, 897; radiotherapy, 323), median time since diagnosis 19 years, and 65,289 noncancer males were included, questionnaire response rates were 60% and 54%, respectively. There were more current smokers (prevalence ratio; 1.14, 95% confidence interval (CI): 1.03–1.26) and patients with body mass index above 25 kg/m$^2$ (prevalence ratio; 1.10, 95% CI: 1.01–1.20) among testicular cancer survivors than in the reference population. Testicular cancer survivors reported less sedentary lifestyle (prevalence ratio; 95% CI: 0.74, 0.64–0.85) and everyday drinkers were fewer (prevalence ratio; 0.79, 95% CI: 0.68–0.92) than in the reference population.

**Conclusion:** We identified smoking cessation as primary target for intervention studies in testicular cancer survivors. The effect of smoking cessation interventions as part of treatment should be investigated. Whether drug-based intervention is effective in minimising the risk of exposure to conventional risk factors for cardiovascular disease is also of interest.

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## Introduction

Adverse health behaviours such as smoking, heavy alcohol consumption, sedentary lifestyle and overweight are associated with increased mortality of cardiovascular disease (CVD) [1–4] and cancer related death [2,5–7] in non-cancerous populations. Rough estimates suggest that intervention against adverse health behaviours in normal populations can reduce CVD with 80% [8] and cancer with 50% [9]. The most effective intervention is smoking cessation [8,9].

Compared to the background population, testicular cancer patients treated with platinum-based chemotherapy, have an increased risk of cardiovascular death and secondary malignancy [10,11].

Efforts to minimise treatment burden without compromising survival outcomes have included reduction in radiation fields and doses [12], and a reduction from four to three cycles of bleomycin, etoposide and cisplatin (BEP) in patients belonging to the good prognostic group according to The International Germ Cell Cancer Collaborative Group Classification [13] It may be difficult to further minimise treatment burden without compromising survival, and therefore health behaviour changes could be of importance to further reduce the risk of CVD and secondary malignancy.

Little is known about health behaviours in testicular cancer survivors (TCS). The purpose of the present study was to clarify the prevalence of smoking, alcohol consumption, sedentary lifestyle and overweight in a national population of long-term TCS compared with a reference population to identify opportunities for interventions to reduce the risk of CVD and secondary malignancy in testicular cancer patients.

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Supplemental data for this article can be accessed here.

## Material and methods

This is a nationwide cross-sectional study of patients included in the Danish Testicular Cancer (DaTeCa) database which houses extensive information on testicular cancer patients diagnosed and treated between January 1984 and December 2007 [14].

Between November 2014 and December 2016, we conducted a national questionnaire survey assessing late effects and health behaviours in TCS including patients registered in the DaTeCa database who were alive by November 2014 and living in Denmark. In total, 4271 TCS were eligible and 2572 (60%) accepted inclusion after written informed consent. The characteristics of non-responders ($N = 1699$) versus responders have been described in detail previously [15]. In brief, there were no significant differences in comorbidity, decade of treatment or place of living (urban versus rural), however, responders were younger and more responders were living in a paired relationship.

We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline [16].

### Testicular cancer survivor cohort and testicular cancer treatment

Out of the 2572 TCS, we excluded patients with bilateral cancer ($N = 81$), those treated with high dose chemotherapy and stem cell transplant in first line ($N = 11$) and patients treated with more than one line of treatment ($N = 85$). These groups were excluded due to small group size and/or heterogeneous population characteristics, leaving 2395 TCS for analysis. Most patients with clinical stage I disease were treated with orchiectomy only and followed on a five-year surveillance programme (surveillance). Patients with disseminated disease were treated with orchiectomy and standard chemotherapy (BEP) or abdominal radiotherapy (RT) and these groups included both patients with disseminated disease at time of diagnosis and patients with initial clinical stage I disease and later relapse. Adjuvant RT was administered in a specific time period to patients with clinical stage I seminoma deemed high-risk (tumour size $\geq$ 6 cm) [17].

### Reference population

Men above 16 years of age from the Danish National Health Survey 2013 acted as reference population [18]. This population was a random nationwide sample from the Danish population who were invited to fill in a questionnaire on health-related variables [19]. The response rate was 54% and 74.550 men participated. For the present study we excluded 9261 (12%) men due to present or prior cancer leaving 65.289 who served as the reference population in the analyses.

### Demographics

Socio-demographic variables were included as they have an impact on health behaviours [20,21]. Age and time since diagnosis were measured in years and evaluated as continuous variables. Education status was dichotomised into long-cycle higher education (five years in university or equivalent) or no long-cycle higher education. Civil status was dichotomised as married or unmarried. Working status was divided into three categories; employed, pensioned or unemployed. In the Danish National Health Survey, participants were classified as pensioned if they were older than 65 years equivalent to the general retirement age in Denmark. For the sake of comparison, the same definition was applied in the TCS. Demographics were self-reported from questionnaires except age and civil status which were obtained from the Danish Civil Registration System [22].

### Health behaviour outcomes

All anthropometry and health behaviours were self-reported from questionnaires. Height and weight were assessed as continuous variables. Body Mass Index (BMI, kg/m$^2$) was calculated and grouped in three categories normal ($<$ 25 kg/m$^2$), overweight ($\geq$25 kg/m$^2$) or obese ($\geq$ 30 kg/m$^2$). Smoking habits were registered with three levels; current (daily and occasionally), former and never smoking. Alcohol consumption was registered in four categories: (maximum once a week, 2–4 days a week, 5–6 days a week and every day). Exercise was registered based on the performance in their leisure time on an average week (competitive sports, moderate: $\geq$4hours a week, modest: $<$4 h a week or sedentary lifestyle).

Adverse health outcomes were defined as BMI $\geq$25 kg/m$^2$, current smoking, alcohol consumption every day and sedentary lifestyle.

### Smoking behaviour at time of diagnosis and at time of questionnaire

In a subset of TCS, data on smoking habits were available at time of diagnosis retrieved from hospital files (January 1984–December 2007) and at time of filling in the questionnaire (November 2014–December 2016). We used this subset of TCS to investigate change of smoking behaviours.

### Health believes

Questions about health believes were asked to TCS only. These questions were included to clarify motivation in TCS to obtain and maintain healthy behaviours.

### Statistics

Descriptive statistics are presented as medians with interquartile ranges (IQR) for continuous variables and with numbers and percentages for all others. In TCS, all variables had less than 2% missing data except education which had 3%. In the reference population, all variables had less than 2% missing data except education which had 5% missing.

An UpSet plot was computed to show combinations of adverse health behaviours with proportions in TCS and the

reference population. To assess prevalence of adverse health behaviours in TCS, binary logistic regression was used to calculate prevalence ratios for each adverse health outcome. In all analyses, we compared with the reference population. First, an age-adjusted model assessed binary adverse health outcomes. Secondly, the binary logistic model was adjusted for age and categories of socio-demographic status (level of education, marital status and working status).

Apart from the binary logistic model, we used a likelihood ratio test to compare models with all TCS together and models with TCS divided into treatment groups on all adverse health behaviour outcomes and both age- and multivariable adjusted. If the likelihood ratio test responded with *p*-values less than 0.05, we concluded that dividing into treatment groups added more information to the model.

Differences between treatment groups who were current smokers at diagnosis and were current smokers at time of questionnaire survey were evaluated with independent *t*-test. In all analyses, a *p*-value less than 0.05 was considered statistically significant. Statistical analyses were performed in IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp and R software version 3.6.2 (R Core Development Team, Vienna, Austria).

## Results

Demographic characteristics of TCS and the reference population are presented in Table 1. The median age of the 2395 TCS was 53 years, while the median age of the reference population was 52 years. In TCS, 49% were treated with orchiectomy only (surveillance), 38% with BEP and 13% with RT and median time since diagnosis was 19 years.

Regarding number of courses in TCS treated with BEP, 262 were treated with three courses, 519 were treated with four courses, 48 were treated with more than four courses, 10 were treated with less than three courses and 58 were treated with an unknown number of courses.

Anthropometry and health behaviours are presented in Table 2. Median BMI was similar between TCS and the reference population and the proportion of men with a BMI $\geq$25 was 62% among TCS and 58% in the reference population. The proportion of current smokers was 22% both among TCS and in the reference population, while BEP-treated patients had the highest proportion of current smokers with 26%. Proportions of everyday alcohol consumption and sedentary lifestyle were lower among TCS than in the reference population.

Combinations of adverse health behaviours were assessed and plotted in Figure 1. Overall, TCS and the reference population were similar in terms of combinations and proportions. In TCS, the combination of two adverse health behaviours with the highest proportion was BMI more than 25 kg/m$^2$ and current smoking with 8.9% as compared to 7.5% in the reference population. Current smoking, BMI $\geq$ 25 kg/m$^2$ and sedentary lifestyle was the most prevalent combination of three adverse health behaviours and proportions was 2% in TCS and 2.1% in the reference population. Proportions of all four adverse health behaviours combined were 0.2% in TCS and 0.4% in the reference population.

Age- and multivariable-adjusted analyses are presented in Figure 2.

More TCS had a BMI $\geq$ 25 kg/m$^2$ than the reference population with an age-adjusted prevalence ratio of 1.14 (95% CI, 1.04–1.24, $p < 0.01$) and a multivariable adjusted prevalence ratio of 1.10 (95% CI, 1.01–1.20, $p = 0.03$). The likelihood ratio test *p*-value, age-adjusted: 0.72, multivariable adjusted: 0.73 indicated no further explanation of the higher BMI between treatment groups.

Age-adjusted prevalence of current smoking did not seem to differ between TCS and the reference population, prevalence ratio 1.07 (95% CI, 0.97–1.18, $p = 0.19$), however, after multivariable adjustments, more TCS were current smokers, prevalence ratio: 1.14 (95% CI, 1.03–1.26, $p < 0.05$). There was further explanation of the higher smoking prevalence among

**Table 1.** Demographic characteristics of testicular cancer survivors and the reference population.

| | Reference | All TCS | Surveillance | BEP | RT |
|---|---|---|---|---|---|
| Total number | 65,289 | 2395 | 1175 | 897 | 323 |
| Age at survey, years | | | | | |
| 16–44, no. (%) | 22,492 (34) | 524 (22) | 223 (19) | 263 (29) | 38 (12) |
| 45–54, no. (%) | 12,809 (20) | 819 (34) | 392 (33) | 317 (35) | 110 (34) |
| 55–64, no. (%) | 13,168 (20) | 672 (28) | 348 (30) | 215 (24) | 109 (34) |
| 65–102, no. (%) | 16,820 (26) | 380 (16) | 212 (18) | 102 (12) | 66 (20) |
| Time since diagnosis, years | | | | | |
| 7–14, no. (%) | NA | 814 (34) | 383 (33) | 311 (35) | 120 (37) |
| 15–24, no. (%) | NA | 1136 (47) | 571 (48) | 420 (47) | 145 (45) |
| 25–33, no. (%) | NA | 445 (19) | 221 (19) | 166 (18) | 58 (18) |
| Long cycle higher education[a], no. (%) | | | | | |
| Yes | 7453 (12) | 421 (18) | 206 (18) | 162 (19) | 53 (17) |
| No | 54,280 (88) | 1880 (82) | 918 (82) | 711 (81) | 251 (83) |
| Married, no. (%) | | | | | |
| Yes | 40,027 (61) | 1589 (66) | 801 (68) | 561 (63) | 227 (70) |
| No | 25,262 (39) | 806 (34) | 374 (32) | 336 (37) | 96 (30) |
| Working status[b], no. (%) | | | | | |
| Employed | 34,404 (53) | 1649 (70) | 791 (69) | 654 (74) | 204 (65) |
| Pensioned | 20,826 (32) | 564 (24) | 302 (26) | 167 (19) | 95 (30) |
| Unemployed | 9329 (15) | 137 (6) | 60 (5) | 63 (7) | 14 (5) |

*Missing data*: There was less than 2% of missing data except for 'Long cycle higher education' which had 3% missing in TCS and 5% missing in the reference population. IQR: interquartile range; TCS: testicular cancer survivors; BEP: Bleomycin, etoposide, cisplatin; RT: Radiotherapy.
[a]Five year in university or equivalent.
[b]Participants was classified as pensioned if they were pensioned before 65 years, in addition all above age 65 year was classified as pensioned.

**Table 2.** Anthropometry and health behaviours characteristics in testicular cancer survivors and the reference population.

| | Reference | All TCS | Surveillance | BEP | RT |
|---|---|---|---|---|---|
| **Body mass index, kg/m$^2$** | | | | | |
| <25 (normal), no. (%) | 27,235 (42) | 878 (38) | 424 (37) | 348 (40) | 106 (34) |
| ≥25 (overweight), no. (%) | 36,843 (58) | 1455 (62) | 532 (63) | 533 (60) | 206 (66) |
| ≥30 (obese), no. (%) | 9608 (15) | 373 (16) | 184 (16) | 135 (15) | 54 (17) |
| **Smoking status, no. (%)** | | | | | |
| Never | 28,780 (44) | 989 (42) | 480 (41) | 385 (43) | 124 (39) |
| Former | 22,037 (34) | 860 (36) | 450 (39) | 279 (31) | 131 (41) |
| Current | 13,976 (22) | 531 (22) | 236 (20) | 229 (26) | 66 (21) |
| **Alcohol consumption, no. (%)** | | | | | |
| Maximum once a week | 30,216 (47) | 1181 (50) | 565 (48) | 470 (53) | 146 (46) |
| 2–4 days a week | 21,430 (33) | 781 (33) | 386 (33) | 284 (32) | 111 (35) |
| 5–6 days a week | 4738 (7) | 193 (8) | 100 (9) | 63 (7) | 30 (9) |
| Every day | 7607 (12) | 224 (9) | 115 (10) | 76 (9) | 33 (10) |
| **Exercise, no. (%)** | | | | | |
| Competitive sports | 4411 (7) | 99 (4) | 44 (4) | 45 (5) | 10 (3) |
| Moderate ≥ 4 h, week | 17,368 (27) | 729 (31) | 374 (32) | 266 (30) | 89 (28) |
| Modest < 4 h, week | 32,653 (51) | 1313 (55) | 633 (54) | 493 (55) | 187 (58) |
| Sedentary lifestyle | 9098 (14) | 246 (10) | 122 (10) | 88 (10) | 36 (11) |

*Missing data*: All variables had less than 2% of missing data. IQR: interquartile range; TCS: testicular cancer survivors; BEP: Bleomycin, etoposide, cisplatin; RT: radiotherapy; h: hours.

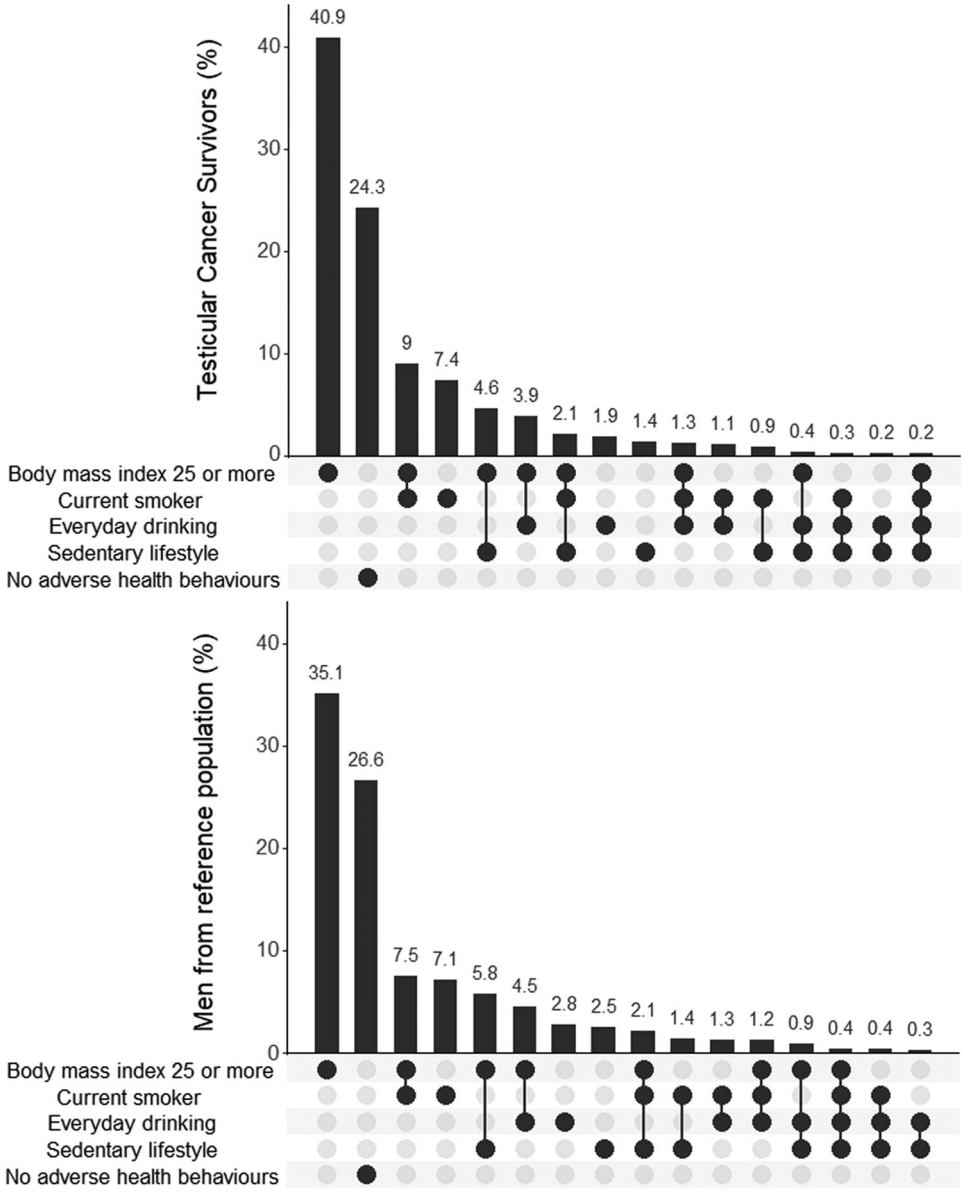


**Figure 1.** UpSet plots presenting adverse health behaviours as single or combinations in percentage among testicular cancer survivors and the reference population. Circles illustrate single adverse health behaviours and circles vertically connected with thin line illustrates combinations of different adverse health behaviours.

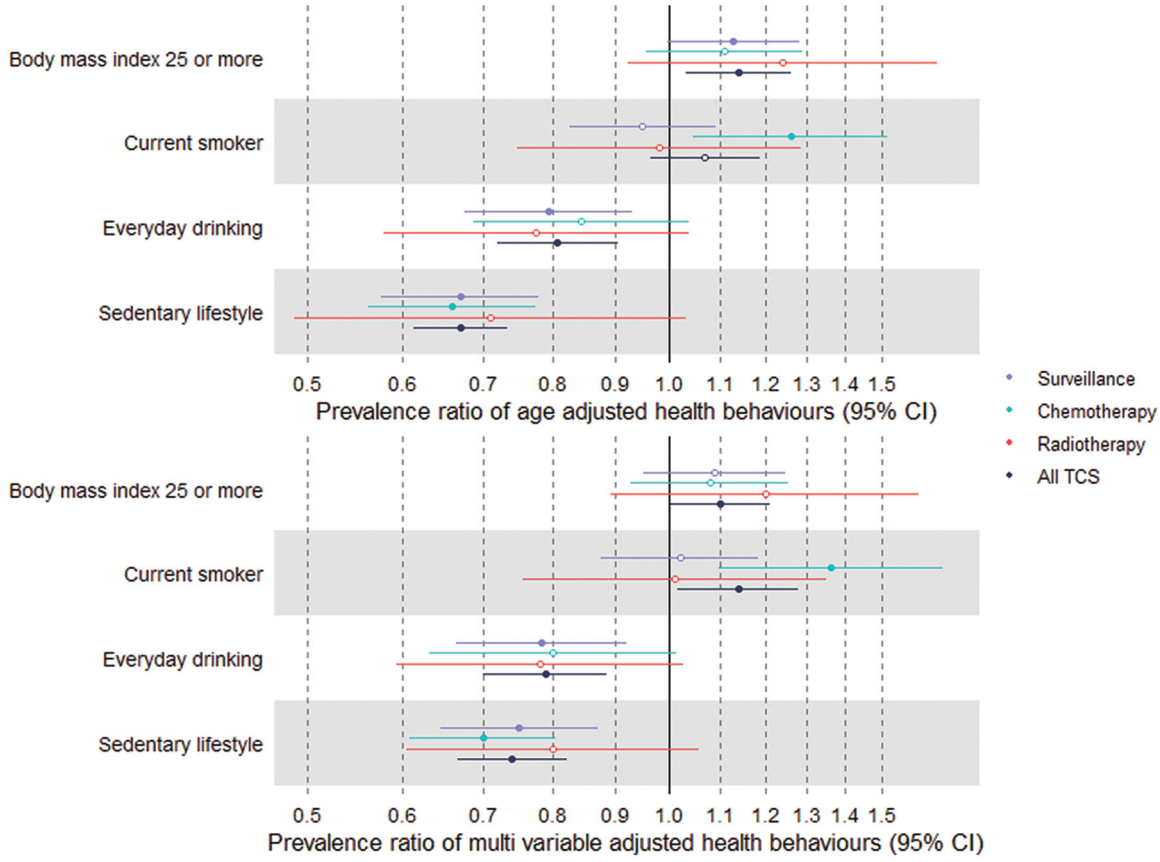


**Figure 2.** Age- and multivariable adjusted prevalence ratios of adverse health behaviours in testicular cancer survivors (TCS) presented as forest plots, stratified by type of treatment and with the reference population as reference (illustrated with black full drawn line through 1.0). *p*-value more than 0.05 are non-significance (displayed with hollow markers). Multivariable adjusted for age, working status, civil status and educational status. CI: confidence interval.

TCS after dividing into treatment types as likelihood ratio test *p*-values were 0.024 (age-adjusted) and 0.019 (multivariable adjusted). BEP-treated survivors had the highest prevalence of smoking with multivariable-adjusted prevalence ratio 1.36 (95% CI: 1.16–1.59, $p < 0.01$).

Lower levels of everyday alcohol consumption were observed among TCS compared with the reference population as the age-adjusted prevalence ratio of everyday drinking was 0.81 (95% CI, 0.70–0.93, $p < 0.01$) and 0.79 (95% CI, 0.68–0.92, $p < 0.01$), respectively, after multivariable adjustment. The likelihood ratio test *p*-value, age-adjusted: 0.90, multivariable adjusted: 0.99 indicated no significantly further explanation of everyday drinking between treatment groups.

Fewer TCS had a sedentary lifestyle as the age adjusted prevalence ratio of sedentary lifestyle was 0.67 (95% CI, 0.59–0.77, $p < 0.01$) when comparing all TCS with the reference population and 0.74 (95% CI, 0.64–0.85, $p < 0.01$) after multivariable adjustment. The likelihood ratio test p-value, age-adjusted: 0.93, multivariable adjusted: 0.84 indicated no further explanation of sedentary lifestyle between treatment groups.

We evaluated change of smoking status in a subset of TCS included in the present study. Among 1326 TCS (42% surveillance, 45% BEP and 13% RT) with time since diagnosis of median 18 years (IQR 12–25) current smoking was prevalent in 527 TCS (40%) at diagnosis and 315 (24%) at time of questionnaire (Supplementary Table 1). Proportions of TCS who kept smoking between diagnosis and questionnaire was 60% for all TCS and 51%, 67% and 58% for surveillance, BEP and RT, respectively.

In total, 91% of TCS reported that they believed it is important or very important to do something to stay healthy and 84% reported that they did something to maintain a good health (Supplementary Tables 2 and 3). For the TCS who reported that they did something to maintain a good health, the majority reported that they were physically active (77%), did not smoke (76%), ate a healthy diet (64%) and/or kept contact to family and friends (62%) (Supplementary Table 4). There were no differences between treatment groups in column proportions except in Supplementary Table 4 where more TCS treated with RT than BEP answered 'I try to eat less', more BEP than surveillance treated patients answered 'I try to stop smoking or smoke less' and more surveillance than BEP treated patients answered 'I try to get enough sleep'.

## Discussion

In this nationwide study, we sought to clarify adverse health behaviours that, on top of treatment, may influence the incidence of secondary malignancies and CVD in TCS. The main findings were a higher proportion of smokers and BMI $\geq 25\,kg/m^2$ among TCS compared to a reference population.

A comparison with the largest published studies on adverse health behaviours in TCS is shown in Table 3 [23–25].

**Table 3.** Study characteristic and prevalence of health behaviours in studies with TCS and control groups.

| Author | Current study | | Shinn et al. (2010) | | Fung et al. (2017) | | Haugnes et al. (2010) | |
|---|---|---|---|---|---|---|---|---|
| Group | TCS | Control | TCS | Control | TC | Control | TCS | Control |
| Diagnosis calendar year | 1984–2007 | NA | NA | NA | 1979–2015 | NA | 1980–1994 | 1986–2001 |
| Assessment calendar year | 2014–2016 | 2013 | 2000–2002 | 2000–2002 | 2014–2017 | 2009–2012 | 2007–2008 | 2007-2008 |
| No. Patients/controls | 2395 | 65289 | 162 | 74[a] | 952 | 952 | 990 | 990[b] |
| Country | Denmark | Denmark | US | US | US | US | Norway | Norway |
| Source | National cohort | National cohort | MD Anderson Cancer centre | Relatives to TCS | US + Canada | NHANESg | National cohort | Tromsø study |
| Age diagnosis, years, median (range) | 34 (15–82) | – | NA | – | 31 (15–53) | – | 31 (15–53) | 32 (13–60) |
| Age follow-up, years, median (range) | 53 (25–95) | 52 (16–102) | 37 (20–59) | 39 (20–59) | 37 (19–68) | NA | 51 (31–69) | 51 (33–70) |
| Follow-up, years, median (range) | 19 (7–33) | – | Mean 4.5, SE 1.6 | – | 4.3 (1.0–29.9) | – | 19 (13–28) | 21 (6–22) |
| **Treatment,** % | | | | | | | | |
| Surveillance | 49 | – | NA | – | 0 | – | 21 | – |
| Chemotherapy | 37 | – | NA | – | 100 | – | 39 | – |
| Radiotherapy | 13 | – | NA | – | 0 | – | 37 | – |
| Other | 0 | – | NA | – | 0 | – | 3 | – |
| **Prevalence health behaviours,** % | | | | | | | | |
| BMI $\geq$ 25 kg/m$^2$ | 62 | 58 | NA | NA | 74.3 | 73.7 | NA | NA |
| BMI $\geq$ 30 kg/m$^2$ | 16 | 15 | NA | NA | NA | NA | 17 | 23 |
| Current smokers | 22 | 22 | 17.9 | 16.2 | 8.3 | 30 | 22 | 20 |
| Sedentary lifestyle | 10 | 14 | 18.5 | 12.2 | NA | NA | 8 | 22 |
| Heavy drinking | 9 | 9 | 32.7[c] | 31.1[c] | 11.4[d] | NA | NA | NA |

[a]Age-matched relatives.
[b]Frequency match in 5-year age groups, nothing stated about present or prior cancer in controls, [c]*Heavy drinking* defined as five or more drinks at one time in past month.
[d]*Heavy drinking* defined as two or more drinks daily.
TCS: Testicular cancer survivors; US: United States; NHANES: National Health and Nutrition Examination Survey; SE: Standard error; Chemotherapy: Patients primarily treated with bleomycin, etoposide, cisplatin but other regimens also included; BMI: Body mass index.

In short, some differences exist between the present study and the comparison studies, especially regarding year of diagnosis, country-specific behaviours, time since diagnosis and number of patients and controls included, which may explain some of the variation. The prevalence of current smokers among TCS in the present study (22% among all TCS and 26% among patients treated with BEP) is in line with the findings on all TCS smoking habits in two of the studies [23,25]. One study reported a surprisingly low prevalence of current smokers (8%) which the authors explained by effective smoking cessation interventions provided by the hospital [24]. The high prevalence of current smokers among TCS treated with BEP is a worrying finding as testicular cancer patients treated with cisplatin-based chemotherapy carry the greatest risk of developing both new cancer and CVD [10,11]. In a systematic review evaluating the risk of lung cancer after treatment of Hodgkin's lymphoma, cigarette smoking seemed to multiply the risk of lung cancer associated with both chemotherapy and radiotherapy [26]. In another study, it was estimated that 9.6% of all lung cancers after Hodgkin's lymphoma were due to treatment, 24% were due to smoking, and 63% were due to treatment and smoking in combination [27]. Similar data do not exist for testicular cancer, but it has been shown that testicular cancer patients treated with BEP have an increased risk of lung cancer compared to a reference population and cigarette smoking might be a contributing factor [10].

Regarding smoking and the risk of CVD, a study including 2512 TCS with a median follow-up of 18 years, found that recent smoking was associated with a 2.6-fold increased risk of myocardial infarction [28]. In our subset analysis, more BEP-treated TCS continued to smoke compared to the surveillance group, emphasising that interventions for smoking cessation are needed. It has been suggested that a cancer diagnosis is a teachable moment for health behaviour changes [29], and the effect of smoking cessation interventions as part of treatment should be investigated. We do not know why TCS and especially BEP-treated patients continue smoking after diagnosis, but nicotine addiction, lack of smoking cessation interventions, and psychological stress have been suggested as possible reasons [30]. In a recent study on the same cohort, we observed a higher level of psychological stress among TCS compared to the reference population, and highest level of stress was found among BEP-treated TCS [31]. Therefore, interventions to address psychosocial stress may also be an important part of smoking cessation efforts and so far, only one study has evaluated smoking cessation in TCS. In this study of 341 long-term TCS many changed their tobacco habits after diagnosis, while only a minority became sustained quitters [32].

Current smoking was reported by 22% in both the population of TCS and the reference population. With multivariable adjustment we identified a 14% increase in prevalence corresponding to an increase from 22% to 25% which roughly corresponds to three additional smokers per 100 TCS. It could be discussed whether such difference is clinically significant and/or could justify health interventions targeting smoking in TCS. However, we would argue that this difference is clinically meaningful and advocate that TCS should rather smoke less compared to controls considering the increased risk of CVD and secondary malignant neoplasms.

We found no evidence of a more sedentary lifestyle in TCS compared to the control group despite signs of being overweight. One explanation for overweight could be the inherent risk in testicular cancer patients for having various degrees of hypogonadism [33]. However, no studies have prospectively evaluated the risk of weight gain in testicular cancer patients and compared it with testosterone levels.

As shown in Table 3, a nationwide Norwegian study found a 17% prevalence of BMI $\geq$ 30 kg/m$^2$ compared to 16% in the present study [25]. However, the prevalence of BMI $\geq$ 30 kg/m$^2$ among the 990 controls included in the Norwegian study was substantially higher than among controls in the present study 23% versus 15%, and the Norwegian study reported a significantly lower BMI in TCS treated with cisplatin-based chemotherapy or radiotherapy compared to controls. These conflicting findings might be explained by different characteristics of the control groups.

Although the proportion of BEP treated TCS with sedentary lifestyle was not different from the control group in the present study, there was an overall 55% of TCS with modest or no physical exercise. In Hodgkin's lymphoma patients, two studies have examined the effects of physical inactivity on CVD risk after treatment. One study with a median time since diagnosis of 11.9 years observed a lower risk of treatment-related cardiac events in childhood Hodgkin's lymphoma survivors with physical exertion corresponding to 2–2.5 h of cycling or walking [34]. Another study with a median time since diagnosis of 19 years showed that patients with a high level of physical activity (>4 h a week of walking, cycling, or sports) had a considerably lower risk of developing CVD than patients who were inactive (1 h a week) [35]. There is no reason to believe that this does not apply for TCS as well, and underlines encouragement of physical activity and the importance of control of conventional CVD risk factors. This means maintenance or adoption of good health behaviours and appropriate management of CVD risk factors to reduce the risk of premature cardiac disease. In this regard, control of blood pressure, cholesterols, blood sugar and testosterone levels are important.

Large studies have shown that in contrast to BEP treated patients, TCS followed on a surveillance programme do not have increased risk of new cancer and CVD [10,11] and, in the present study, the number of current smokers among surveillance were comparable to the reference population, in addition, more patients in the surveillance group were able to quit smoking. Other than smoking, we observed no differences in health behaviours between BEP treated and patients in the surveillance group.

An encouraging finding was that fewer TCS than controls were consuming alcohol every day. However, this finding is difficult to compare with data from the other studies mentioned in Table 3 due to lack of data and differences in study designs.

The majority of TCS in the current study (91%) were aware that a positive effort must be made to stay healthy, however, only 84% answered that they did something to

maintain good health (such as being physically active, avoiding stress and/or getting enough sleep). Implying that the majority of TCS are motivated for a change in health behaviour but might need guidance to conduct healthier lifestyle.

Strengths of the present study include the population-based nationwide study design, with a large sample size, sociodemographic covariates, accurate treatment data and a large comparable reference population. The cross-sectional study design is a limitation and a prospectively designed study is needed to confirm our findings. As the comparison cohort came from another survey, we cannot rule out that the observed differences between the TCS and the comparison cohort were not random, however, both surveys had many similarities, study design, calendar year of study period and response-rates. Another possible limitation is that we did not have any measures of health behaviours before testicular cancer diagnosis or during the 5-year follow-up program. However, the scope of this study was to investigate health behaviours in long term TCS as other studies have look at health behaviours during the 5-year follow-up program [23,24]. In the analysis with smoking status at diagnosis and after, the assessment was done with separate methods, however, this is still the largest assessment with the longest time since diagnosis on smoking status conducted. We did not have information on health literacy which could be a possible mediating factor, however, we adjusted for socioeconomic status which is associated with health literacy.

## Conclusion

In particular, adverse health behaviours in BEP-treated patients should be in focus. Preventive strategies in TCS should include health behaviour interventions specifically aimed at smoking cessation and the effect of smoking cessation interventions as part of treatment should be investigated. Whether drug-based intervention is effective in minimising the risk of exposure to conventional risk factors for cardiovascular disease should be highlighted.

## Ethical approval

All procedures performed in the study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent: Informed consent was obtained from all individual participants included in the study.

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## Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Michael Kreiberg, Mikkel Bandak, Jakob Lauritsen, Cathrine Juel Lau, Klaus Kaae Andersen and Gedske Daugaard. The first draft of the manuscript was written by Michael Kreiberg and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

## Disclosure statement

The authors declare that they have no conflicts of interest.

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## Data availability statement

The dataset generated analysed during the current study are available from the corresponding author on reasonable request.

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