Physical activity, alcohol consumption, BMI and smoking status before and after prostate cancer diagnosis in the ProtecT trial: Opportunities for lifestyle modification

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Associations between certain lifestyle characteristics and prostate cancer risk have been reported, and continuation post-diagnosis can adversely affect prognosis. We explored whether men make spontaneous changes to their physical activity and alcohol intake, body mass index (BMI) and smoking status, following a diagnosis of localised prostate cancer. A detailed diet, health and lifestyle questionnaire was completed by 511 participants within the Prostate Testing for Cancer and Treatment (ProtecT) randomised controlled trial, both before and 9 months after a diagnosis of prostate cancer. Of 177 men who were insufficiently active before their diagnosis (median 0 activity units/week; IQR 0–9), 40.7% had increased their activity by a median of 22 U week\(^{-1}\) (IQR 15–35) 9 months later, and there was weak evidence that men were more active after diagnosis (\(p = 0.07\)). Men categorised as “working” occupational social class and who were insufficiently active before diagnosis were 2.03 (95%, CI 1.03–3.99, \(p = 0.04\)) times more likely to have increased their physical activity levels compared to men classified as “managerial or professional.” Similarly, men who were insufficiently active pre-diagnosis and with T-stage 2 compared with T-stage 1 prostate cancer were 2.47 (95%, CI 1.29–4.71, \(p = 0.006\)) times more likely to be sufficiently active post-diagnosis. Following diagnosis, there was an overall reduction in alcohol intake (\(p = 0.03\)) and the proportion of current smokers (\(p = 0.09\)), but no overall change in BMI. We conclude that some men spontaneously change certain lifestyle behaviours on receiving a diagnosis of prostate cancer. For many men, however, additional support through lifestyle interventions is probably required to facilitate and maintain these changes.

Prostate cancer is the most common male cancer in England: one in eight UK men will be diagnosed in their lifetime and the disease accounted for a quarter of all new cancer diagnoses in 2010.\(^{1}\)

Despite inconclusive evidence linking the development of prostate cancer to modifiable behaviours, associations with diet and lifestyle have been reported.\(^{2}\) Furthermore, sedentary behaviour,\(^{3}\) a high alcohol intake,\(^{4}\) obesity\(^{5}\) and continuing to smoke,\(^{6}\) following cancer diagnosis are associated with a worsening of prognosis. Nevertheless, there is little consistent evidence that a cancer diagnosis is associated with sustained healthy lifestyle changes.\(^{7}\) Positive spontaneous dietary

Key words: prostate cancer, behaviour change, randomised control trial

Abbreviations: ASAP: atypical small acinar proliferation; BMI: body mass index; DHL: diet and lifestyle questionnaire; HGPIN: high-grade prostatic intraepithelial neoplasia; HTA: health technology assessment; IQR: inter-quartile range; NIHR: national institute for health research; PCa: prostate cancer; ProtecT: UK prostate testing for cancer and treatment randomised controlled trial; PSA: prostate specific antigen

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changes are made by some men following a prostate cancer diagnosis; however, this is not always the case. Some men with prostate cancer have shown small but significant weight gain, whereas survivors of other cancer sites lost weight and reduced their tobacco and alcohol consumption. Less than 25% of those living with cancer meet recommended physical activity guidelines. Almost 50% of smokers continued after a diagnosis of prostate cancer. Data for alcohol consumption following a prostate cancer diagnosis are limited. Data for other cancer sites are reported: for example 16% of lung cancer survivors reported being abstinent, although site specific differences are likely.

Following a cancer diagnosis, many consider whether changing their lifestyle will slow their disease progression, and what advice to give is an important public health and clinical issue. Any post diagnosis behaviour changes may result from a “teachable moment,” a naturally occurring event thought to motivate spontaneous risk-reducing behaviours. This could be an opportunity to engage with patients and implement positive lifestyle changes. We explored whether men make spontaneous changes to their levels of physical activity and alcohol intake, body mass index (BMI) and smoking status, following a diagnosis of localised prostate cancer.

Material and Methods
Design and participants
The men in this study were participants in the prostate testing for cancer and treatment (ProtecT) randomised controlled trial. In total, 82,429 men aged 50–69 years, with no previous history of prostate cancer, had a prostate specific antigen (PSA) test. Men with a raised PSA level (≥3.0 ng ml−1) underwent a biopsy n = 7,414, of whom n = 6,181 were sent a diet, health and lifestyle questionnaire. Those subsequently diagnosed with clinically localised prostate cancer n = 1,872 were offered randomisation to one of three treatments. Participants were not routinely provided with lifestyle advice. Full ethics approval was obtained from Trent MREC (number 01/4/025).

Health behaviour assessment
Men completed a diet, health and lifestyle questionnaire at recruitment into the ProtecT study. This included questions about height, weight, physical activity, alcohol consumption and smoking. In total, 1,872 men were eligible and allocated (accepted randomisation or patient preference) to one of the three treatments, and sent a follow-up diet, health and lifestyle questionnaire at either 12, 24, 36, 48, 60 or 72 months post-recruitment. We only included men who were mailed a second diet, health and lifestyle questionnaire at 12 months, 9 months post-diagnosis (821 of 1,872; 43.9%) in order to minimise variability of follow-up time intervals, to focus on spontaneous behaviour change post diagnosis and due to small samples at the latter time points (Fig. 1). Changes in diet data are reported elsewhere.

Figure 1. Flow diagram of study recruitment. Abbreviations: ProtecT: prostate testing for cancer and treatment; PSA: prostate specific antigen; DHL: diet, health, and lifestyle questionnaire; HGPIN: high-grade prostatic intraepithelial neoplasia; ASAP: atypical small acinar proliferation; PC: prostate cancer. Numbers may differ to other publications due to being a sub section of the ProtecT population, percentages are relevant to this analysis only.
Table 1. Cross-tabulation of health behaviours pre- and post-diagnosis (including row percentages)

|                  | Physical activity | Post-diagnosis | Test of pre-post change |
|------------------|-------------------|----------------|-------------------------|
|                  | Insufficiently active “Unhealthy” | Sufficiently active “Healthy” | Total | p |
| Insufficiently active “Unhealthy” | N = 105 (59.3%) | N = 72 (40.7%) | N = 177 (100%) |   |
| Sufficiently active “Healthy” | N = 52 (15.9%) | N = 282 (84.4%) | N = 334 (100%) |   |
| Total            | N = 157 (30.7%) | N = 354 (69.3%) | N = 511 | 0.07 |
|                  | Alcohol consumption |                  |                      |
|                  |                    | Total |                      |
|                  | Test of pre-post change |

|                  | Pre-diagnosis | Post-diagnosis | Test of pre-post change |
|------------------|---------------|----------------|-------------------------|
|                  | Above recommended limits – “Unhealthy” | Within recommended limits – “Healthy” | Total | p |
| Above recommended limits “Unhealthy” | N = 151 (75.5%) | N = 49 (24.5%) | N = 200 (100%) |   |
| Within recommended limits “Healthy” | N = 30 (9.6%) | N = 281 (90.4%) | N = 311 (100%) |   |
| Total            | N = 181 (35.4%) | N = 330 (64.6%) | N = 511 | 0.03 |
|                  | BMI            |                  |                      |
|                  | Test of pre-post change |

|                  | Pre-diagnosis | Post-diagnosis | Test of pre-post change |
|------------------|---------------|----------------|-------------------------|
|                  | Above recommended range – “Unhealthy” | Within recommended range – “Healthy” | Total | p |
| Above recommended range “Unhealthy” | N = 326 (95.6%) | N = 15 (4.4%) | N = 341 (100%) |   |
| Within recommended range “Healthy” | N = 22 (12.9%) | N = 148 (87.1%) | N = 170 (100%) |   |
| Total            | N = 348 (68.1%) | N = 163 (31.9%) | N = 511 | 0.32 |
|                  | Smoking status |                  |                      |
|                  | Test of pre-post change |

|                  | Pre-diagnosis | Post-diagnosis | Test of pre-post change |
|------------------|---------------|----------------|-------------------------|
|                  | Current smoker | Non-smoker | Total | p |
| Current smoker    | N = 43 (78.2%) | N = 12 (21.8%) | N = 55 (100%) |   |
| Non-smoker        | N = 5 (1.1%) | N = 451 (98.9%) | N = 456 (100%) |   |
| Total             | N = 48 (9.4%) | N = 463 (90.6%) | N = 511 | 0.09 |

P values derived from McNemar’s test. 1Physical activity—insufficiently active “unhealthy”: <14 U of activity per week. 2Physical activity—sufficiently active “healthy”: 14+ units of activity per week. 3Alcohol—above recommended limits “unhealthy”: above recommended guidelines >21 U activity per week. 4Alcohol—within recommended limits “healthy”: within recommended guidelines ≤21 U activity per week. 5BMI—above recommended range “unhealthy”: ≥25. 6BMI—within recommended range “healthy”: <25. 7Smoking—“unhealthy”: current smoker. 8Smoking—“healthy”: ex-smoker or never smoker.

Physical activity was measured using the Godin and Shephard Leisure-Time Physical Activity Questionnaire, a validated self-report measure. Physical activity was recorded in units (a bout of activity lasting ≥15 min) of mild, moderate or strenuous in the previous week. Total weekly physical activity was calculated according to guidelines, recommending that when considering the health contribution of physical activity, activities listed in the “mild” category should be excluded: total activity = (9*strenuous units) + (5*moderate units), and then dichotomised into “sufficient to achieve health benefits” (14+ units of activity per week) and “insufficient to achieve health benefits” (<14 U of activity per week) according to Godin’s cut-points. The amount and frequency of beer, spirits or wine were combined and converted into standard UK alcohol units. UK Department of Health guidelines for safe alcohol consumption were used to dichotomise alcohol consumption into lower (“within recommended guidelines” ≤21 U week−1) or elevated (“above recommended guidelines” >21 U week−1) risk of adverse health effects. BMI was calculated from self-reported weight (kg)/height (m), and dichotomised into “within recommended range” (BMI < 25) and “above recommended range” (BMI ≥ 25) according to WHO guidelines. Smoking status was defined as current smoker, ex-smoker or never smoker, and dichotomised into “current smoker” or “non-smoker” (“ex-smoker” and “never smoker” combined).

**Socio-demographic and clinical exposures**

Age, marital status and social class at time of diagnosis were considered potential socio-demographic exposures as these variables have previously been shown to influence behaviour. Prostate cancer T-stage at baseline was considered a...
potential clinical exposure. Age was dichotomised into: 50–59 years, and 60–70 years. Marital status was dichotomised into “married/living with partner” and “Single, divorced, widowed or separated.” Social class, using the Standard Occupational Classification 2000, was categorised into “managerial and professional,” “Intermediate” and “Working.”

Statistical analysis

The study sample comprised men who provided complete diet, health and lifestyle data pre-diagnosis and 9 months post-diagnosis, and complete socio-demographic data. Men not meeting these inclusion criteria were excluded in the main analyses. We compared the clinical and socio-demographic characteristics of those included/excluded in the main analysis to identify any systematic differences that could indicate a selection bias.

Dichotomised health behaviours were termed “healthy” if they were within recommended limits (alcohol and BMI), sufficient for health benefits (physical activity), or non-smokers, as described previously; and “unhealthy” if they were the alternative category. McNemar’s test determined whether participants changed their behaviour from a “healthy”/“unhealthy” state before diagnosis to an “unhealthy”/“healthy” state after diagnosis. Where behaviour change was evident (\( p < 0.1 \)), binary logistic regression models, stratified by pre-diagnosis health status, were used to assess whether the exposures were associated with post-diagnosis health status.

To assess whether current findings differed according to the study sample definition, the statistical analyses were repeated individually for men who had complete data for each of the lifestyle characteristics (sample sizes: physical activity \( n = 641 \), BMI \( n = 566 \), alcohol consumption \( n = 680 \)).

Results

Our study sample was 511 (62.2%) of the 821 potentially eligible men, who provided complete PA, alcohol consumption, BMI and smoking data. Men were aged 62.3 years on average (range 50 to 70). No difference was found between those who were included in the main analysis, where evidence of differences was noted (Supporting Information Table 1).

| Pre-diagnosis physical activity | Post-diagnosis physical activity | Pre-diagnosis alcohol consumption | Post-diagnosis alcohol consumption |
|--------------------------------|---------------------------------|----------------------------------|----------------------------------|
| OR (95% CI) | \( p \) | OR (95% CI) | \( p \) | OR (95% CI) | \( p \) | OR (95% CI) | \( p \) |
| Age at diagnosis 50–59 (reference) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 60–70 | 0.53 (0.27 to 1.03) | 0.06 | 0.60 (0.29 to 1.22) | 0.16 | 1.06 (0.52 to 2.16) | 0.87 | 1.61 (0.70 to 3.66) | 0.26 |
| Social class Managerial and professional (reference) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Intermediate | 1.61 (0.65 to 4.01) | 0.30 | 0.72 (0.30 to 1.75) | 0.47 | 1.58 (0.60 to 4.13) | 0.35 | 1.41 (0.48 to 4.12) | 0.53 |
| Working | 2.03 (1.03 to 3.99) | 0.04 | 1.19 (0.60 to 2.36) | 0.63 | 1.14 (0.55 to 2.35) | 0.73 | 1.76 (0.74 to 4.18) | 0.20 |
| Marital status Married (reference) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Single, divorced, widowed or separated | 0.64 (0.21 to 1.92) | 0.43 | 1.19 (0.48 to 2.93) | 0.71 | 0.76 (0.26 to 2.23) | 0.62 | 0.96 (0.31 to 2.97) | 0.95 |
| T-stage Stage 1 (reference) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Stage 2 | 2.47 (1.29 to 4.71) | 0.006 | 1.39 (0.62 to 3.14) | 0.43 | 0.75 (0.33 to 1.71) | 0.49 | 2.65 (0.77 to 9.10) | 0.12 |

Odds ratios are adjusted for all exposures simultaneously. \(^1\) Physical activity—insufficiently active “unhealthy”: <14 U of activity per week. \(^2\) Physical activity—sufficiently active “healthy”: 14+ U of activity per week. \(^3\) Alcohol—above recommended limits “unhealthy”: above recommended guidelines’ >21 U activity per week. \(^4\) Alcohol—within recommended limits “healthy”: within recommended guidelines’ <21 U activity per week.

Table 2. Adjusted logistic regression models for odds of being sufficiently active for health benefits and consuming alcohol within recommended limits post-diagnosis, stratified by pre-diagnosis status

**Potential clinical exposure.** Age was dichotomised into 50–59 years, and 60–70 years. Marital status was dichotomised into “married/living with partner” and “Single, divorced, widowed or separated.” Social class, using the Standard Occupational Classification 2000, was categorised into “managerial and professional,” “Intermediate” and “Working.”

**Analysis**

The study sample comprised men who provided complete pre-diagnosis and 9 months post-diagnosis health and lifestyle data. Men meeting these inclusion criteria were included in the main analyses. We compared the clinical and socio-demographic characteristics of those included/excluded in the main analysis to identify any systematic differences that could indicate a selection bias.

Dichotomised health behaviours were termed “healthy” if they were within recommended limits (alcohol and BMI), sufficient for health benefits (physical activity), or non-smokers, as described previously; and “unhealthy” if they were the alternative category. McNemar’s test determined whether participants changed their behaviour from a “healthy”/“unhealthy” state before diagnosis to an “unhealthy”/“healthy” state after diagnosis. Where behaviour change was evident (\( p < 0.1 \)), binary logistic regression models, stratified by pre-diagnosis health status, were used to assess whether the exposures were associated with post-diagnosis health status.

To assess whether current findings differed according to the study sample definition, the statistical analyses were repeated individually for men who had complete data for each of the lifestyle characteristics (sample sizes: physical activity \( n = 641 \), BMI \( n = 566 \), alcohol consumption \( n = 680 \)).
(median = 23.5 kg m\(^{-2}\), IQR = 22.5–24.1 kg m\(^{-2}\)) (Table 1). The remaining 341 men (66.7%) had a median BMI of 28.0 kg m\(^{-2}\) (IQR 26.4–29.8 kg m\(^{-2}\)). Prior to diagnosis 55 men (10.8%) reported being a current smoker (Table 1).

### Change in lifestyle characteristics

Of the 177 men who were initially in the “unhealthy” group for physical activity, 72 (40.7%) increased their activity levels by a median of 22 U week\(^{-1}\) (IQR 15–35 U week\(^{-1}\)) and were classified in the “healthy” group post-diagnosis (Table 1). Of the 334 men in the “healthy” physical activity group pre-diagnosis, 52 (15.9%) decreased their activity by a median of 25 U week\(^{-1}\) (IQR −35 to −15 U week\(^{-1}\)) at follow-up. There was weak evidence to support an overall increase in physical activity from pre- to post-diagnosis (\(p = 0.07\)).

Men who were insufficiently active pre-diagnosis and who were categorised as of “working” occupational class compared with managerial and professional men were 2.03 (\(p = 0.04\), 95% CI = 1.03–3.99) times more likely to be sufficiently active post-diagnosis (Table 2). Similarly, men who were insufficiently active pre-diagnosis and with T-stage 2 prostate cancer compared with T-stage 1 prostate cancer were 2.47 (95% CI = 1.29–4.71, \(p = 0.006\)) times more likely to be sufficiently active post-diagnosis. There was no evidence of associations between age at diagnosis or marital status and the men being sufficiently active after the diagnosis.

Of the 200 men in the “unhealthy” group for alcohol consumption pre-diagnosis, 49 (24.5%) reduced their alcohol consumption by a median of 12.8 U week\(^{-1}\) (IQR = −18.1 to −6.7 U week\(^{-1}\)) and were reclassified into the “healthy” intake level post-diagnosis (Table 1). However, of the 311 men in the “healthy” group for alcohol consumption pre-diagnosis, 30 men (9.6%) increased their alcohol consumption by a median of 12.8 U week\(^{-1}\) (IQR = 8.3–26.1 U week\(^{-1}\)). There was weak evidence of an overall reduction in alcohol consumption from pre- to post-diagnosis (\(p = 0.03\)).

There was no evidence of associations between age at diagnosis, social class marital status or prostate cancer T-stage and “healthy” levels of alcohol consumption after diagnosis (Table 2).

Of 341 men who were initially in the “unhealthy” group for BMI, 28 (8.2%) lost a clinically meaningful amount (>5%) of their body weight and 15 (4.4%) changed BMI category to “healthy” post-diagnosis (Table 1). Their median change was −1.7 kg m\(^{-2}\) (IQR −2.5 to −0.9 kg m\(^{-2}\)). Additionally, 22 men (12.9%) increased their body weight and moved in the opposite direction. Their median change was 1.1 kg m\(^{-2}\) (0.9–1.7 kg m\(^{-2}\)). There was no evidence of an overall change in BMI from pre- to post-diagnosis (\(p = 0.32\)).

A total of 12 men (21.8%) who smoked prior to diagnosis (\(n = 55\)) reported being a non-smoker at follow-up, whereas five men (1.1%) took up smoking post-diagnosis (Table 1). There was weak evidence to support a change in smoking behaviour (\(p = 0.09\)), although considering the small sample no further analysis was undertaken.

The results of our sensitivity analyses (not reported), in which study samples were defined for each of the lifestyle characteristics individually, did not differ from the reported results.

### Discussion

Weak evidence suggests that a diagnosis of localised prostate cancer may result in increased physical activity levels 9 months later. This is especially evident in those classified as working class, who were twice as likely to increase their physical activity levels, compared to men in managerial and professional occupations. Working class men may have had higher levels of ‘unhealthy’ physical activity behaviour initially,\(^{21}\) increasing opportunities for transition to ‘healthy’ behaviour. Alternatively, if working class social norms dictate higher levels of ‘unhealthy’ behaviour,\(^{21}\) a diagnosis could allow for justification of a move towards ‘healthy’ behaviour. Those with T-stage-2 who were insufficiently active pre-diagnosis were twice as likely to be sufficiently active post-diagnosis, compared with T-stage-1. A positive change was seen in alcohol intake and smoking behaviours post-diagnosis. No large changes were observed for BMI. It should be considered that a control group was not available for direct comparison; however older populations are reported to be significantly underactive, with BMI, overweight and obesity being higher than younger age groups.\(^{22}\) There is no convincing evidence from the literature that older men routinely and spontaneously make lifestyle changes. Research indicates that many are sedentary and do not intend to increase physical activity.\(^{23}\)

Pre-diagnosis, the majority of men drank less alcohol than the recommended maximum guidelines and only a small proportion were smoking. Although over half were sufficiently active for health benefits pre-diagnosis, those who were insufficiently active were sedentary, with a weekly physical activity median of zero units. Over two-thirds had a BMI score above the recommendations at diagnosis. This highlights the need for interventions to improve lifestyle factors in this population, in particular diet and physical activity interventions that could increase physical activity levels, and reduce subsequent BMI.

One of our proposed explanations for the association between physical activity and social class was that working class men had higher levels of “unhealthy” behaviour initially. This is supported by exploratory analysis of physical activity stratified by social class; before diagnosis a higher proportion of working class men were insufficiently active for health benefits compared with intermediate and managerial classes respectively (40.2%, 38.5% and 28.6%). After diagnosis this had reduced to 37.1%, 30.8% and 26.0%.

Our data support findings that, on average, some people with cancer stop smoking\(^{11}\) and reduce their alcohol consumption.\(^{12}\) The overall increase in physical activity is in-line with other studies (in prostate and breast cancer),\(^{11}\) although another study showed an increase in sedentary behaviour.
post-diagnosis. A prostate cancer diagnosis may create a teachable moment for some; however, the spontaneous behaviour changes that we observed were not as substantial as documented elsewhere.

Prostate cancer may prompt a different behaviour change response compared to other cancers. It may be perceived to have a less severe impact on general health, resulting in fewer spontaneous changes. Gender differences may affect the response to a teachable moment; women have previously demonstrated a larger response. Older patients may be less likely to adopt new behaviours; additionally, females may be more likely to make changes.

To facilitate spontaneous change, it is important to make lifestyle interventions available to newly diagnosed patients; this is particularly relevant as not all men reported making behaviour changes, which have been shown to improve prognosis. These can be employed at any time, although the largest positive impact on health professionals follow-up and smoking) in a positive (healthy) direction following diagnosis and treatment. Cancer survivors may need better support and accessible interventions to promote positive and sustained behaviour change. There is currently insufficient evidence of exactly what these interventions should be and whether they are feasible or effective in this population.

A key strength of our study is that it is based on a large, well defined sample with longitudinal follow-up of health behaviours. However, there are limitations. In the absence of a control group we cannot definitively conclude that the changes resulted from cancer diagnosis. The population was a research-based screen-detected sample, which may not be representative of a routinely detected clinical population. A healthy screen effect may occur, where those who attend screening are healthier, have lower smoking rates or are motivated to improve health. A clinically detected population of men may be less likely to make spontaneous changes. The sub-groups in the study were relatively small, especially current smokers, reducing power. Self-reported measures may be subject to recall and response biases to promote social desirability. The strength of the study is that pre-diagnosis measures were reported prior to knowledge of the PSA screening test result.

Conclusion

We observed that some men spontaneously changed certain lifestyle behaviours (physical activity levels, alcohol consumption and smoking) in a positive (healthy) direction following a diagnosis of localised, screen-detected prostate cancer. Such changes may occur as a result of the prostate cancer diagnosis acting as a teachable moment. Cancer survivors may need better support and accessible interventions to promote positive and sustained behaviour change. There is currently insufficient evidence of exactly what these interventions should be and whether they are feasible or effective in this population.

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Appendix

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