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Research Article

The association between behavioral habits and physical health status in prostate cancer patients: a large US national health-related survey

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ABSTRACT

Background: The impact of behavioral habits such as exercise on the physical health of prostate cancer (PCa) patients is poorly understood. We aimed to investigate PCa patients' exercise habits and the association between exercise and self-reported physical health status.

Methods: The 2016–2020 Behavioral Risk Factor Surveillance System (BRFSS) databases were used to identify men with a history of PCa. We identified patients with self-reported PCa diagnosis and excluded the non-male gender respondents in the self-reported PCa patients. We performed descriptive statistics and multivariable logistic regression analysis examining the association between exercise and poor physical health status. Our exposure of interest was the amount of physical exercise, and primary outcome was poor physical health status, defined as >14 self-reported days per month when patients felt "physical health is not good." Covariates included age, body mass index (BMI), income, treatment, smoking, and exercise frequency.

Results: From 2,193,981 weighted survey participants, we identified 3,952 men with a history of PCa. Of these, 75% of participants reported exercise within the last month. In adjusted analyses among men with a history of PCa, exercise (OR 0.50, 95% CI 0.40–0.64, $P < 0.001$) was associated with lower odds of poor physical health status. Other independent predictors of poor physical health included income (High: OR 0.27, 95% CI 0.18–0.41, $P < 0.01$), BMI (underweight: OR 3.78, 95% CI 1.38–10.37, $P = 0.01$), treatment status (Active: OR 1.76, 95% CI 1.05–2.94, $P = 0.03$), smoking status (Active: OR 1.64, 95% CI 1.13–2.38, $P = 0.01$).

Conclusion: Our BRFSS cross-sectional study concluded that exercise among men with a history of PCa, even once per month, is associated with decreased odds of self-reported poor physical health; therefore, exercise programs should be considered for sedentary PCa patients.

1. Introduction

Prostate cancer (PCa) is the most common non-skin malignancy in men, and approximately 1 in every 8 men will be diagnosed with PCa during his lifetime in the United States.[1] Morbidity related to treatment includes urinary incontinence, erectile dysfunction, and various musculoskeletal and cardiometabolic health problems.[2–4] Interventions improving PCa outcomes and surgical complications are necessary, although studies of the impact on patients' physical health after cancer diagnosis and treatment are limited.

Exercise is proven to positively impact many diseases,[5,6] with beneficial effects on health and quality of life (QoL) for urologic cancer patients.[7,8] Data have shown that high-intensity interval training in men on active surveillance for localized PCa, including 12 weeks of regular, supervised aerobic sessions on a treadmill at 85% to 95% of peak oxygen consumption, was associated with

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increased cardiorespiratory fitness levels, as well as decreased PSA levels, PSA progression, and PCa cell growth.[9] Exercise may additionally preserve physical function, alleviate the adverse effects of undergoing therapy, or improve QoL.[8,10,11] Postdiagnosis physical activity is inversely associated with cause-specific and all-cause mortality among men with a PCa history.[12] As such, men with a PCa history characterize an important target population for health promotion efforts.

Although exercise seems to improve PCa-related outcomes, previous studies have shown that only 30% of PCa survivors meet the CDC recommendations for physical activity levels.[13] On the other hand, some other comorbidities, including smoking and obesity, have also been stated to be associated with the physical activity and physical health status of PCa patients.[14,15] Therefore, in this study, using a large national survey, we examined the association between exercise, health-related variables and self-reported physical health of PCa patients. We hypothesized that physical activity among men with a history of PCa may have a beneficial impact on their self-reported physical health status.

2. Materials and methods

2.1. Data source

An institutional review board waiver (protocol number: 2015P000341) was obtained in concordance with the Brigham and Women's Hospital regulations regarding the use of de-identified administrative data.

We used the Behavioral Risk Factor Surveillance System (BRFSS), the largest continuous national system of health-related surveys that collect data about U.S. citizens regarding health-related risk behaviors, chronic conditions, and the use of preventive services that can affect their health status. The survey was conducted monthly over landline telephones and cellular phones with a standardized questionnaire by the Centers for Disease Control and Prevention (CDC). The BRFSS questionnaire was designed and approved by a working group of BRFSS state coordinators and CDC staff.[16] We extracted data from BRFSS years 2016 to 2020. These data reflect respondent-reported health behaviors and represent non-overlapping annual cohorts.[17]

2.2. Study population

We merged the BRFSS datasets from year 2016 to 2020. The variable CNCRTYP1 for the question," What type of cancer was it?" was used to identify patients with self-reported PCa diagnosis. We excluded the non-male gender respondents in the self-reported PCa patients (Fig. 1).

2.3. Outcome measure and covariates

Our primary exposure of interest was the amount of physical exercise. The respondents were asked, "during the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?," which was coded Yes/No. Respondents reporting no exercise in the last month were considered sedentary. The primary outcome of interest was self-reported health status among men with a history of PCa, and the respondents were asked, "now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?" Physical health status was then coded into binary 0–13 versus 14+ days of poor physical status per month from 0, 1–13, or 14+ days for statistical analysis.

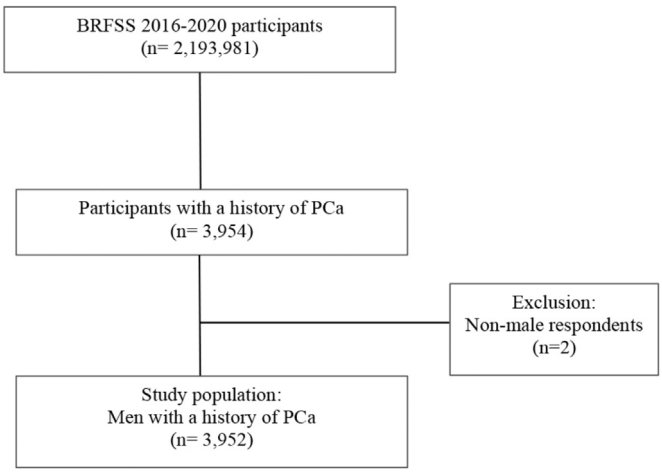

Figure 1. Flow Chart of Study Population Selection.

Covariates included age, physical health status, body mass index (BMI), treatment status, income, and smoking status. BMI level was divided into four categories, we coded BMI <18.50 "underweight," 18.50–24.99 "normal," 25.00–29.99 "overweight," and 30.00–99.99 "obese." Annual household income level was obtained by asking the respondents, "What is your annual household income from all sources?," which was coded in four levels, "≤$14,999," "$15,000–$24,999," "$25,000–$34,999," "$35,000–$49,999," and "≥$50.000." Treatment status, depending on the respondent's reply to the question, "Are you currently receiving treatment for cancer?" was grouped into "no, I haven't started treatment," "yes," "no, I've completed treatment," "no, I've refused treatment," "treatment was not necessary," "don't know/not sure." Smoking status was grouped into "never smoked," "current smoker," and "former smoker." Table 1 shows further details on included variables and available responses to each of them. Certain variables were consistently labeled across years of BRFSS datasets, while others were not. Thus, all variables of interest were recorded using a new unifying label before appending the datasets for analysis. We excluded survey questions that were not consistently captured across the survey years.

2.4. Statistical analysis

The statistical analysis consisted of several steps. First, survey weights were applied by using the variable _LLCPWT, which reduced the potential bias resulting from selection probabilities and noncoverage among segments of the population.[17] Second, we used descriptive statistics to report characteristics and differences in demographics between those who reported exercise 0 versus ≥ 1 day per month. The differences among both groups were assessed with Chi-square tests (or Fisher exact tests) for categorical variables. *T*-tests were used for continuous variables. Finally, a multivariable logistic regression model for the outcome of the adjusted binary poor physical health status was performed, adjusting for age, income, smoking status, BMI, cancer treatment, and exercise. A goodness of fit test was used to assess our model, and we conducted an accuracy analysis by the Receiver Operating Characteristic (ROC)-derived area under the curve (AUC) model. ROC analysis yielded an AUC of 0.71.

Two-sided statistical significance was defined as $P < 0.05$. Stata v.16.0 (StataCorp, College Station, TX, USA) was used to perform all statistical analyses.

Table 1
Characteristics of PCa participants in BRFSS data sets between 2016 and 2020

Characteristic variables	Total, % (*n*)	No physical activity or exercise in last 30 days, % (*n*)	Had physical activity or exercise, % (*n*)	*P*-value
All respondents with prostate cancer	100.00 (3,952)	25.13 (993)	74.87 (2,959)	
Physical status				<0.01
≤14 days of poor physical status	85.63 (3,294)	75.18 (721)	89.09[a)] (2,573)	–
>14 days of poor physical status	14.37 (553)	24.82 (238)	10.91[a)] (315)	
Total	*100.00 (3,847)*	*100.00 (959)*	*100.00 (2,888)*	
Four level BMI status				<0.01
Underweight	0.59 (23)	1.02 (10)	0.45[a)] (13)	–
Normal weight	23.56 (918)	21.26 (209)	24.33[a)] (709)	
Overweight	44.29 (1,726)	37.13 (365)	46.71[a)] (1,361)	
Obese	31.56 (1,230)	40.59 (399)	28.52[a)] (831)	
Total	*100.00 (3,897)*	*100.00 (983)*	*100.00 (2,914)*	
Are you currently receiving treatment for cancer?				0.34
No, I haven't started treatment	4.67 (168)	5.57 (51)	4.37 (117)	–
Yes	14.47 (520)	15.50 (142)	14.12 (378)	
No, I've completed treatment	68.64 (2,467)	66.16 (606)	69.49 (1,861)	
No, I've refused treatment/treatment was not necessary	10.85 (390)	11.24 (103)	10.72 (287)	
Don't know/not sure	1.36 (49)	1.53 (14)	1.31 (35)	
Total	*100.00 (3,594)*	*100.00 (916)*	*100.00 (2,678)*	
Income				<0.01
Less than $14,999	4.75 (161)	8.63 (73)	3.46[a)] (88)	–
$15,000–$24,999	12.52 (424)	18.32 (155)	10.59[a)] (269)	
$25,000–$34,999	10.87 (368)	13.83 (117)	9.88[a)] (251)	
$35,000–$49.999	16.45 (557)	18.79 (159)	15.66[a)] (398)	
$50,000 or more	55.42 (1,877)	40.43 (342)	60.41[a)] (1,535)	
Total	*100.00 (3,387)*	*100.00 (846)*	*100.00 (2,541)*	
Smoker status				<0.01
Never smoked	46.05 (1,799)	38.04 (372)	48.72[a)] (1,427)	–
Current smoker	8.24 (322)	13.19 (129)	6.59[a)] (193)	
Former smoker	45.71 (1,786)	48.77 (477)	44.69[a)] (1,309)	
Total	*100.00 (3,907)*	*100.00 (978)*	*100.00 (2,929)*	
Age (continuous)	71.61	72.21	71.40	–

BMI, body mass index.
Italics indicate significant difference between men with a history of PCa who had physical activity and the control group.
[a)] Indicates $P < 0.05$.

3. Results

3.1. Demographic characteristics

Out of 2,193,981 weighted survey participants, we identified 3,952 with a history of PCa (Table 1). All participants were male, with a mean age of 72 (SD = 7.39). Approximately one-fourth (25%, $N = 993$) of participants reported no exercise outside their regular job within the last 30 days. For the BMI status, 44% ($N = 1,726$) of the participants were overweight (BMI 25–29.9), while 32% ($N = 1,230$) were obese (BMI ≥ 30). Regarding treatment in this PCa cohort, 14% were currently undergoing treatment. Most participants had an annual income of over $50,000 (55%). Considering smoking status, 8% ($N = 322$) were current smokers.

3.2. Multivariable logistic regression model

Multivariable analysis demonstrates that exercise was significantly protective against patient-reported poor health (OR 0.51, 95% CI = 0.40–0.64, $P < 0.01$) (Table 2). Specifically, patients doing physical activity outside of regular jobs in the last 30 days had a 2-fold higher probability of reporting good health status compared to their counterparts who were not doing any exercise. Income was an independent predictor of poor physical health status in an incremental dose-dependent fashion. Compared to men with a history of PCa with an annual income <$14,999, those earning more than $50,000 were less likely to report poor physical health ≥14 days per month (OR 0.27, 95% CI 0.18–0.41, $P < 0.01$). Compared to men with a history of PCa that have not started treatment, current treatment was significantly associated with poor physical health status (OR 1.76, 95% CI 1.05–2.94, $P = 0.03$). Compared to men with a history of PCa who never smoked, current smoking was also associated with poor physical health (OR 1.64, 95% CI 1.13–2.38, $P = 0.01$). Finally, compared to normal BMI men with a history of PCa, underweight participants were more likely to report poor physical health ≥14 days per month (OR 3.75, 95% CI, 1.38–10.37, $P = 0.01$).

4. Discussion

We identified three main findings in our study. First, exercise among men with a history of PCa, even as little as one day per month, is associated with decreased odds of self-reported poor physical health (OR 0.51). Second, being underweight is a risk factor for poor physical health status (OR 3.75), while being overweight or obese is not. This suggests that for those facing a PCa diagnosis, nutritional or caloric supplement interventions for underweight patients may be more important than weight loss interventions for those who are overweight or obese. Third, income emerges as a crucial determinant of physical health, exhibiting a dose-dependent relationship. This underscores the need for a more profound understanding and mitigation of the socioeconomic factors driving disparities in outcomes and QoL in patients with a history of PCa.

We found that exercise has a beneficial effect on physical health in patients with a history of PCa. Although we were not able to examine the type and intensity of the exercise of men with a history of PCa in our study due to lacking data, studies have shown that different patterns of exercise may improve the overall well-being of PCa patients.[9,18,19] For example, in the ERASE trial, a group of selected PCa patients was asked to complete 12 weeks of regular,

Table 2
Multivariable adjusted odds ratio of poor physical health >14 days per month between physical activity status, behavioral factors, and biologic factors in men with a history of PCa

Variables	Odds Ratio	95% Conf. Interval	*P*-value
Age (continuous)	0.99	0.98–1.01	0.47
Physical activity outside of regular job in last 30 days			
No physical activity	Ref.	—	—
≥1 day of physical activity	0.51[a)]	0.40–0.64	<0.01
Are you currently receiving treatment for cancer?			
No, I haven't started treatment	Ref.	—	—
Yes	1.76[a)]	1.05–2.94	0.03
No, I've completed treatment	0.74	0.46–1.20	0.23
No, I've refused treatment/treatment was not necessary	0.62	0.35–1.12	0.12
Don't know/not sure	1.46	0.56–3.85	0.44
Income			
less than $14,999	Ref.	—	—
$15,000–$24,999	0.55[a)]	0.35–0.87	0.01
$25,000–$34,999	0.43[a)]	0.26–0.69	0.001
$35,000–$49,999	0.32[a)]	0.20–0.51	<0.01
$50,000 or more	0.27[a)]	0.18–0.41	<0.01
Smoking status			
Never smoked	Ref.	—	—
Current smoker	1.64[a)]	1.13–2.38	0.01
Former smoker	1.14	0.90–1.44	0.29
BMI			
Normal weight	Ref.	—	—
Underweight	3.78[a)]	1.38–10.37	0.01
Overweight	0.88	0.66–1.17	0.37
Obese	1.31	0.98–1.76	0.07

BMI, body mass index; Ref., reference value.
Superscripts indicate significant difference between men with a history of PCa who had physical activity and the control group.
[a)] Indicates $P < 0.05$.

supervised aerobic sessions on a treadmill at 85% to 95% of peak oxygen consumption. The results of this study have shown that high-intensity interval training in men on active surveillance for localized PCa was associated with increased cardiorespiratory fitness levels, as well as decreased PSA levels, PSA progression, and PCa cell growth in men with localized PCa who were under active surveillance.[9] Hojan et al stated that regular, moderate-intensity physical exercise, which involves 30 minutes of aerobic exercise combined with 15 minutes of resistant training, can improve functional capacity, decrease the production of inflammatory markers and fatigue, and has a positive influence on QoL in high-risk PCa patients during radiotherapy.[18] Furthermore, it has been stated that supervised moderate-to-hard resistance training with or without aerobic exercise appears to improve PCa-related fatigue and QoL.[19] In addition, Kim et al stated that regardless of disease stage, the alteration of myokine levels of the patients on androgen deprivation therapy (ADT) after chronic exercise training results in a tumor-suppressive effect. Moreover, an acute session of exercise may result in additional tumor suppression to the anticancer environment established by regular exercise. This mechanism may specifically explain decreased disease progression and increased survival in patients with PCa who are more physically active.[20] However, the causality between physical activity and physical health in PCa patients may be bidirectional and involve complex causality. The reverse causality of better physical health of the PCa patients leading to more physical exercise should not be ruled out. Understanding the interrelationship is important, so further research is needed.

In addition to exercise, we found an association between BMI and self-reported physical health, specifically that being underweight is a significant risk factor for poor physical health status. This may be attributable to cancer cachexia, a cancer-induced wasting syndrome characterized by weight loss, anorexia, asthenia, and anemia.[21] Cachexia is very prevalent in cancer patients, and it occurs approximately in 60% of PCa patients.[22] Evidence shows that patients with cancer cachexia can benefit from exercise, with increased body and muscle mass.[23] Caregivers should consider exercise planning for men with a history of PCa with cancer cachexia to improve physical status. Nutritional interventions should also be recommended since they improve nutrition parameters, body composition, symptoms, QoL, and ultimately survival.[24]

We also found that higher income is associated with lower odds of self-reported poor physical health in an incremental/dose-response pattern in men with a history of PCa. Previous research has demonstrated how lower income among men with a history of PCa is associated with a lower likelihood of receiving definitive cancer treatment, and with a higher mortality.[25] Major et al stated that lower socioeconomic status was associated with higher PCa incidence rates.[26] Using data from the SEER-Medicare linked database, Du et al found that low socioeconomic status was significantly associated with decreased survival in men with PCa. Those living in a community with the lowest quartile of socioeconomic status were 31% more likely to die than those living in the highest quartile.[27] Further, Oake et. al observed that socioeconomic status affects treatment decision-making.[28] Besides treatment, socioeconomic status may also impact a PCa patient's access to exercise facilities, healthy food, and rehabilitation programs, which could all positively support and improve their physical health.[29] Therefore, providing financially accessible physical health interventions can be practical and beneficial for PCa patients.

In our study, it is notable that current treatment in men with a history of PCa significantly correlates with poor physical health. This may be due to adverse effects associated with treatment, including ADT, radiotherapy, or surgery. There have been a great number of studies showing the adverse effects of PCa treatment.[2,30–32] For example, ADT can impair health and QoL due to adverse effects, including decreased bone mineral density and muscle mass, weight gain, increased insulin resistance, impaired cognitive dysfunction, decreased libido, and sexual dysfunction.[3,33] Exercising in cancer patients can alleviate the side effects associated with the treatment, particularly pelvic floor muscle exercise has an important role in effectively improving the urinary incontinence caused by radical prostatectomy.[10,34] Park S et al stated that a structured lifestyle intervention increases self-reported physical activity, decreases self-reported sedentary behavior, and significantly improves the QoL in men on ADT.[35] Further, in the ENGAGE study, men with PCa who participated in clinician referrals to community-based 12-week exercise training programs improved their physical functioning and cardiovascular health, irrespective of whether they were treated ADT.[36] Therefore, in men with a history of PCa, it is important to combine exercise programs and lifestyle interventions with treatment regimens.

There are several limitations to this study. First, the major limitation is that the exact cancer stage and treatment type of the patient are not known due to the survey's design. As discussed above, patients undergoing ADT, with or without additional androgen-directed therapies for metastatic disease, represent a distinct population compared to those with localized disease. Consequently, differences in self-reported physical health would be anticipated between these groups. Second, in this dataset, as stated previously, we only have a binary variable for exercise status, lacking the detailed continuous variable that allows an exploration of how exercise intensity affects physical health status. Also, the type of exercise is unknown, which does not allow a further comparison between aerobic exercise and resistance training. Third, the

optimal assessment of QoL among PCa patients is an area of active debate; while the single BRFSS survey question on physical health status lacks external validity as an unvalidated instrument, it does offer insight into self-reported physical health status and allows for internal comparison. Finally, the BRFSS is a self-reported survey and therefore, may be subject to recall bias and social desirability bias, which may lead to underestimation of poor physical health or overestimation of physical exercise.[37] Telephone-based surveys also lack interpersonal data interpretation and interpretations of responses. Given the study design, inferences about the causality of observed associations cannot be attributed, and these data should only be viewed as hypothesis-generating.[38]

Despite these limitations, by utilizing a large contemporary PCa cohort focused on patient-reported outcomes, we successfully identified the prevalence of sedentary behavior and determined the adverse predictors of poor physical health status in men with a history of PCa. Based on our finding that "exercising even once per month" is associated with decreased odds of poor physical health, healthcare providers should recommend physical activities at least once per month to PCa patients. Literature showed that personal emotional state, social network, and family support are key determinants of physical activity levels in cancer patients.[39] Therefore, strategies regarding exercises after diagnosis and treatment must be carefully developed to improve patient care for men with a history of PCa. The effectiveness of various approaches to modifying lifestyle factors and mitigating socio-economic factors must also be empirically determined in additional implementation studies.

5. Conclusion

Men with a history of PCa exhibit a relatively high activity level, with 75% reporting engagement in exercise within the past 30 days. Exercising among men with a history of PCa, even once per month, is associated with decreased odds of self-reported poor physical health; therefore, while our findings are hypothesis-generating, there is strong evidence for the benefits of physical exercise in general, and therefore this should be emphasized with PCa patients. Healthcare providers should recommend physical activities at least once per month to the subset of sedentary PCa patients. Being underweight, current treatment, active smoking, and lower income are also associated with poor physical health, so multimodal interventions (interventions involving including nutritional support, smoking cessation, socioeconomic concerns, improved access to care, etc.) to additionally support men with a history of PCa in these categories may also lead to independent improvements in physical health.

Conflicts of interest

Q-DT reports consulting fees from Astellas, Bayer, Intuitive Surgical, Janssen, Novartis, Pfizer, and research funding from the American Cancer Society, Pfizer Global Medical Grants (Prostate Cancer Disparities #63354905), and a Health Disparity Research Award from the Department of Defense Congressionally Directed Medical Research Program (#PC220551). The other authors have nothing to disclose.

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