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Association of life's crucial 9 score with benign prostatic hyperplasia: a cross-sectional study

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Abstract

Background Benign prostatic hyperplasia (BPH) and prostate cancer (PCa) are prevalent prostate diseases in aging male populations, with significant implications for quality of life and healthcare burden. While cardiovascular health (CVH) and lifestyle factors have been linked to aging and chronic diseases, their association with prostate diseases remains underexplored.

Objective This study investigates the relationship between CVH, assessed using the Life's Crucial 9 (LC9) score, and the risk of prostate diseases, including BPH and PCa, in a large UK cohort.

Methods Data from 26,656 male participants in the UK Biobank were analyzed. The LC9 score, an expanded CVH metric incorporating mental health, was calculated based on physical, metabolic, and psychological factors. Logistic regression and restricted cubic spline analyses were performed to examine associations between the LC9 score and prostate diseases. Subgroup and interaction analyses were conducted to explore potential modifiers.

Results A higher LC9 score was significantly associated with a lower risk of BPH in both continuous and categorical models ($P < 0.001$). The association demonstrated a linear dose-response relationship, with the inflection point at an LC9 score of 72.5. Subgroup analysis revealed stronger protective effects in participants with lower socioeconomic deprivation. However, no significant association was observed between the LC9 score and PCa risk, even in subgroup analyses.

Conclusions This study highlights the importance of overall cardiovascular and psychological health in reducing BPH risk, emphasizing the need for sustained healthy behaviors. The absence of a significant link between the LC9 score and PCa suggests distinct pathophysiological mechanisms and warrants further research. These findings provide valuable insights for targeted prevention and management strategies in prostate health.

Keywords Cardiovascular health, Prostate diseases, Lifestyle factors, Prevention

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Introduction

Among elderly males, benign prostatic hyperplasia (BPH) is the most common prostate disease, with approximately ~ 8% of men in the fourth decade of life but up to 90% of men in the ninth decade [1]. Epidemiological surveys have reported that this disease affects over 15 million men, particularly those over the age of 50, and is a considerable economic burden on society [2]. And with the aging of the global population, this issue is gaining increasing attention [3]. A significant number of patients with benign prostatic hyperplasia (BPH) do not achieve relief from bladder outlet obstruction despite systematic medical therapy. Ultimately, surgical intervention is required to resolve the obstruction, with minimally invasive transurethral procedures being the current standard of care [4, 5, 6].

In addition to BPH, prostate cancer (PCa) represents another major concern in aging male populations. PCa is the most common non- cutaneous cancer among males, with approximately 1.4 million new cases and 375,000 deaths reported worldwide each year [7]. In 2020, PCa ranked as the fifth-leading cause of cancer-related mortality globally and the second-leading cause in the US [8]. For localized prostate cancer, surgery and radiotherapy remain the primary treatment options. However, side effects such as urinary symptoms and sexual dysfunction can negatively impact quality of life [9, 10]. In metastatic prostate cancer, despite advancements in androgen deprivation therapy and chemotherapy, at least 40% of patients still experience biochemical recurrence [11].

In a recently published perspective, Gaffey and colleagues introduced an updated cardiovascular health (CVH) assessment and quantification tool named Life's Crucial 9 (LC9), based on the previous Life's Essential 8 (LE8) [12, 13, 14]. The LE8, updated and introduced by the American Heart Association (AHA), comprehensively evaluates eight evidence-based CVH metrics encompassing four healthy lifestyle and four health factors, representing a new paradigm for CVH assessment [13]. With emerging evidence on CVH, psychological health was identified as a possible underpinning for the enhancement of the existing LE8 paradigm and as an important dimension in future integrated models of cardiovascular care [12]. While the LC9 score has demonstrated significant associations with cardiovascular and all-cause mortality [15], its association with prostate diseases remains underexplored.

This study aimed to evaluate the association between cardiovascular health, as reflected by the LC9 score, and the risk of prostate diseases (BPH and PCa), with specific hypotheses that higher LC9 scores are inversely associated with incident BPH/PCa risk, and this relationship may be mediated through shared aging or inflammatory pathways. The assessment used data from the UK Biobank. By leveraging comprehensive UK Biobank data, incorporating a wide range of cardiovascular health markers, identifying specific influential factors, conducting stratified analyses and evaluating long-term effects, this study significantly advances the understanding of the relationship between LC9 and prostate diseases. These novel contributions provide valuable insights that can inform prevention and management strategies for BPH and PCa.

Materials and methods

Data source and study populations

The UK Biobank recruited over 500,000 individuals aged 40–69 between 2006 and 2010 across the UK, collecting detailed information on their lifestyle, physical measurements, and biological samples (blood, urine, saliva) for future research [16]. In this study focused on prostate diseases, we excluded female participants ($n = 273, 160$) as the prostate diseases only affects males. Two variables, Diagnoses-ICD10 (Data-field 41270) and Type of cancer: ICD10 (Data-field 40006), were utilized to confirm the presence of BPH and prostate cancer. Participants with missing or incomplete data regarding LC9 factors ($n = 201, 776$) or any other covariates were excluded ($n = 1, 854$), leaving a cohort of male participants with complete information for further analysis (Fig. 1). The UK Biobank access management team approved this analysis, as the Institutional Review Board approved part of application #332,912 and the National Institutes of Health project.

Exposure assessment

According to the American Heart Association's definition of the LE8 scoring, the original version for assessing CVH was developed in the U.S. National Health and Nutrition Examination Survey (NHANES) cohort, while a modified version was implemented in the UK Biobank cohort [13]. The LE8 score consisted of 4 health behaviors (diet, physical activity, nicotine exposure, and sleep duration) and 4 health factors (body mass index, non- high-density lipoprotein cholesterol, blood glucose, and blood pressure). Based on the DASH-style dietary pattern proposed by the AHA, a modified diet score was used in the UK Biobank (see Supplementary File 1: Table S1). Details and scoring algorithms for each CVH indicator in these cohorts are provided in Supplementary File 1: Table S2.

In brief, each of the eight CVH indicators is scored from 0 to 100, with scores assigned by an expert panel using a refined Delphi method based on health outcomes and risk associations. The overall LE8 score is calculated as the average of the eight indicator scores.

Depression assessment was performed using the validated Patient Health Questionnaire-9 (PHQ-9), a 9-item depression module derived from the full Patient Health

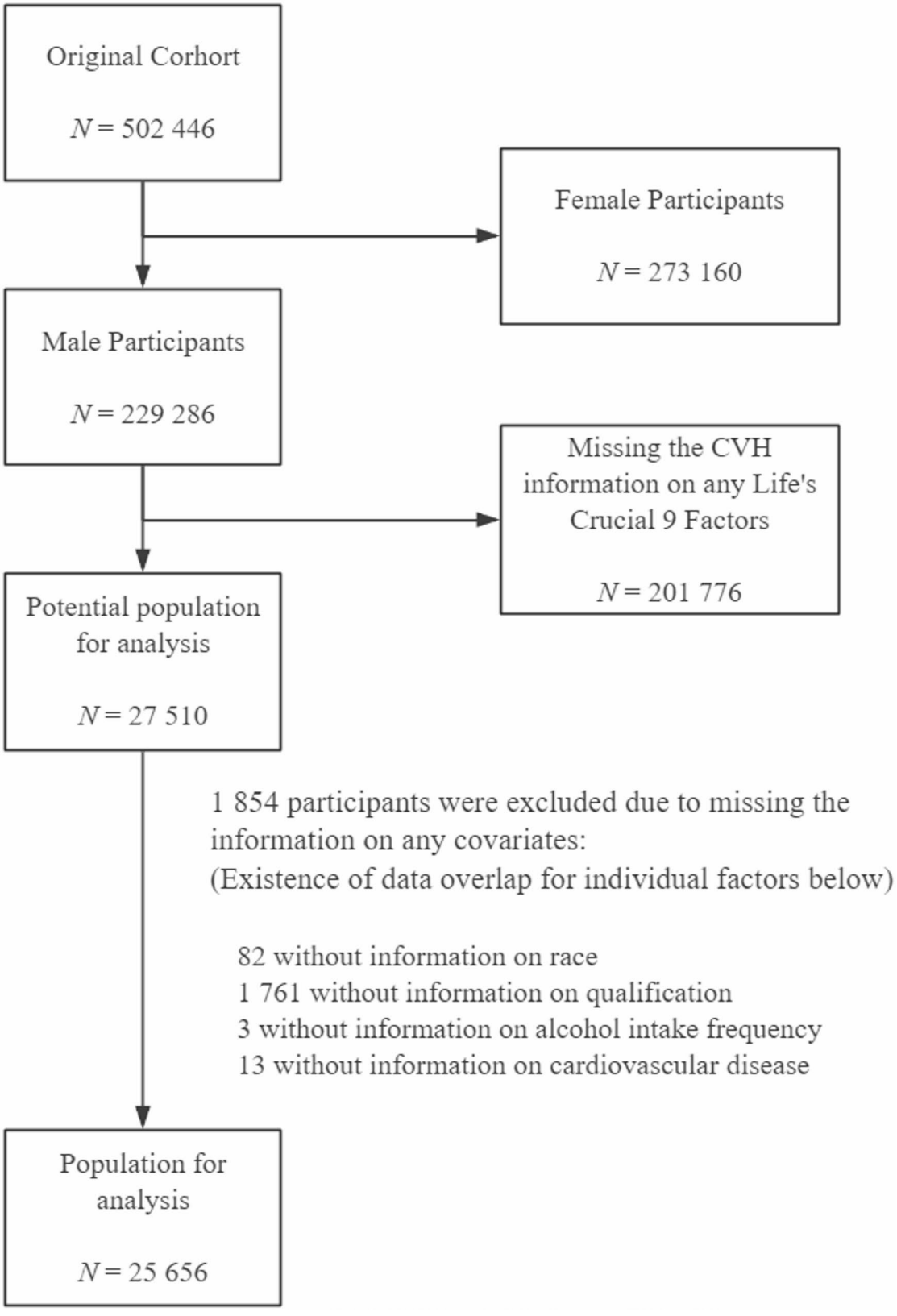

Fig. 1 Flowchart showing the selection of the studied population in UKB cohort

Questionnaire (see Supplementary File 1: Table S4). It is widely used as a severity measure, with scores ranging from 0 to 27, as each of the 9 items can be rated from 0 ("not at all") to 3 ("nearly every day"). Higher scores indicate more severe depressive symptoms. When the PHQ-9 score falls within the ranges of 0–4, 5–9, 10–14, 15–19, and 20–27, the corresponding depression ratings by the clinical team are 100, 75, 50, 25, and 0, respectively [17]. The LC9 score is calculated as the average of the LE8 score and the depression score [15].

Covariates

The potential confounding factors in the UK Biobank cohort were assessed, and we collected comprehensive health-related data, including questionnaire responses, physical examinations, biochemical markers, and medical history. The variables of the UK Biobank we included in this study are as follows: Age (continuous), race/ethnicity (White, Mixed, Asian or Asian British, Black or Black British, Chinese, and Other Ethnic Group), qualification (College or University degree, A levels/AS levels or equivalent, O levels/GCSEs or equivalent, CSEs or equivalent, NVQ or HND or HNC or equivalent, and other professional qualifications), Townsend deprivation index (continuous, derived from postal code data on unemployment, car and home ownership, and household overcrowding; higher scores indicate lower socioeconomic status, applicable only to the UK Biobank), body mass index (BMI, continuous), Alcohol intake frequency (Daily or almost daily, Three or four times a week, Once or twice a week, One to three times a month, Special occasions only, Never), as well as medical history of hypertension, diabetes and cardiovascular disease (CVD).

Statistical analysis

In order to facilitate statistics, some of the above variables were integrated into new variables. According to the World Health Organization (WHO) criteria, age was categorized into two groups: younger and middle-aged individuals (less than 60 years) and older adults (60 years or above). BMI was classified into four categories: underweight (BMI < 18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2), and obese (30–39.9 kg/m^2) [18]. The education level of participants was categorized into three degrees: less than high school, high school or equivalent, and college or above, according to qualification (Data-field 6138). The Townsend Deprivation Index variable was divided into three groups (Q1, Q2, Q3) based on tertiles. The situation of alcohol was a generalization of alcohol intake frequency. Participants whose alcohol intake frequency was never were categorized as no, while others were categorized as yes.

Participants were divided into four groups (Q1-Q4) based on the quartiles of the LC9 score. Chi-square tests were applied for categorical variables. Logistic regression was used to analyze the relationship between the LC9 score and prostate diseases occurrence. To evaluate the robustness of the findings, we conducted a series of sensitivity analyses. First, we constructed multivariable regression models with stepwise covariate adjustments to assess the consistency of results across different levels of adjustment. The unadjusted model (Model 1) did not control for any potential confounders. Partially adjusted model (Model 2) was adjusted for age, ethnicity, education, Townsend Deprivation Index and BMI. Fully adjusted model (Model 3) was further adjusted for alcohol use status and the medical history of hypertension, diabetes and CVD. Additionally, 1,854 participants were excluded from the main analysis due to missing covariate data. To explore the potential impact of this exclusion, we repeated the analysis using the full cohort before covariate exclusion. The results remained consistent, supporting the robustness of our primary findings.

Restricted cubic splines (RCS) were also used to visualize the association between the LC9 score and prostate diseases occurrence. The number of knots in the RCS model was determined based on the Akaike Information Criterion (AIC); specifically, we compared models with varying numbers of knots and selected the one with the lowest AIC value. Subgroup analyses were stratified by age category, ethnicity, Townsend Deprivation Index category, education level, BMI category, alcohol use, hypertension history, diabetes history and CVD history. Multiplicative interaction tests were conducted to examine the interactions between the LC9 score and these stratifying factors.

All statistical analyses in this study were conducted using R version 4.3.1, with a two-sided P-value < 0.05 considered to indicate statistically significant differences.

Result

Baseline characteristics

We first provide an overview of the baseline characteristics of the study population in the UK Biobank cohort. As shown in Table 1, for the UK Biobank database, a total of 26,656 participants were included in the study for the calculation of LC9 score, and participants were grouped into four categories. The Q1 group included 6,597 participants, Q2 had 6,402 participants, Q3 had 6,285 participants, and Q4 had 6,372 participants. Compared with individuals in the first quartile of LC9 score, those in the fourth quartile had lower BMI [24.61(23.11–26.59) vs. 28.70(26.06–31.71)] and a higher percentage of college education (61.0% vs. 44.0%). In LC9 quartile 4, the occurrence rates of high blood pressure (10.0% vs. 25.0%), diabetes (0.3% vs. 11.1%) and CVD (2.8% vs. 8.1%) were lower than in LC9 quartile 1.

Table 1 The baseline characteristics by quartiles of the LC9 score

Characteristic	Overall *N* = 25,656	Q1 *N* = 6,597	Q2 *N* = 6,402	Q3 *N* = 6,285	Q4 *N* = 6,372	*p*-value[1]
BPH, n (%)						< 0.001
No	22,669 (88)	5,733 (87)	5,620 (88)	5,585 (89)	5,731 (90)	
Yes	2,987 (12)	864 (13)	782 (12)	700 (11)	641 (10)	
Prostate Cancer, n (%)						0.090
No	24,212 (94.4)	6,246 (94.7)	6,039 (94.3)	5,894 (93.8)	6,033 (94.7)	
Yes	1,444 (5.6)	351 (5.3)	363 (5.7)	391 (6.2)	339 (5.3)	
Age, n (%)						< 0.001
60 or above	10,290 (40)	2,430 (37)	2,888 (45)	2,667 (42)	2,305 (36)	
less than 60	15,366 (60)	4,167 (63)	3,514 (55)	3,618 (58)	4,067 (64)	
Race, n (%)						0.049
ASIAN OR ASIAN BRITSH	241 (0.9)	63 (1.0)	49 (0.8)	56 (0.9)	73 (1.2)	
BLACK OR BLACK BRITSH	124 (0.5)	40 (0.6)	34 (0.5)	30 (0.5)	20 (0.3)	
CHINESE	31 (0.1)	11 (0.2)	5 (< 0.1)	6 (< 0.1)	9 (0.1)	
MIXED	90 (0.4)	32 (0.5)	26 (0.4)	14 (0.2)	18 (0.3)	
Other ethnic group	114 (0.4)	35 (0.5)	31 (0.5)	27 (0.4)	21 (0.3)	
WHITE	25,056 (97.7)	6,416 (97.2)	6,257 (97.7)	6,152 (97.9)	6,231 (97.8)	
Townsend Deprivation Index, n (%)						< 0.001
Q1	8,505 (33)	1,888 (29)	2,130 (33)	2,162 (34)	2,325 (36)	
Q2	8,447 (33)	2,117 (32)	2,125 (33)	2,118 (34)	2,087 (33)	
Q3	8,704 (34)	2,592 (39)	2,147 (34)	2,005 (32)	1,960 (31)	
Qualifications, n (%)						< 0.001
college or above	13,370 (52)	2,924 (44)	3,147 (49)	3,402 (54)	3,897 (61)	
high school	3,479 (14)	1,001 (15)	874 (14)	809 (13)	795 (13)	
less than high school	8,807 (34)	2,672 (41)	2,381 (37)	2,074 (33)	1,680 (26)	
BMI, n (%)						< 0.001
low	39 (0.2)	6 (< 0.1)	5 (< 0.1)	10 (0.3)	18 (0.4)	
normal	4,751 (19)	639 (9.9)	731 (11)	1,034 (16)	2,347 (37)	
obesity	5,074 (20)	2,589 (39)	1,723 (27)	605 (9.7)	157 (2.6)	
overweight	15,792 (61)	3,363 (51)	3,943 (62)	4,636 (74)	3,850 (60)	
Alcohol consumption, n (%)						< 0.001
Current	24,721 (96.4)	6,285 (95.2)	6,216 (97.1)	6,101 (97)	6,119 (96.1)	
Never	384 (1.5)	97 (1.5)	72 (1.1)	79 (1.3)	136 (2.1)	
Previous	551 (2.1)	215 (3.3)	114 (1.8)	105 (1.7)	117 (1.8)	
Hypertension, n (%)						< 0.001
No	19,269 (75)	4,098 (62)	4,402 (69)	5,037 (80)	5,732 (90)	
Yes	6,387 (25)	2,499 (38)	2,000 (31)	1,248 (20)	640 (10)	
Diabetes, n (%)						< 0.001
No	24,537 (95.6)	5866 (88.9)	6107 (95.4)	6209 (98.8)	6355 (99.7)	
Yes	1,119 (4.4)	731 (11.1)	295 (4.6)	76 (1.2)	17 (0.3)	
CVD, n (%)						< 0.001
No	24,316 (94.8)	6,065 (91.9)	6,012 (95.9)	6,044 (96.2)	6,195 (97.2)	
Yes	1,340 (5.2)	532 (8.1)	390 (6.1)	241 (3.8)	177 (2.8)	

[1]Kruskal-Wallis rank sum test; Pearson's Chi-squared test

The relationship between the LC9 score and BPH

We initially investigated the relationship between the LC9 score and BPH occurrence, the results were illustrated in Table 2. When considering the LC9 score as a continuous factor, all models showed a significant negative association with the outcome (all $p < 0.001$). In the sensitivity analysis, after dividing LC9 score into quartiles and comparing relative to LC9 quartile 1, we found that the odds of BPH for individuals in the third or fourth quartile of LC9 score were statistically significant in model 1 (Q3: OR 0.83, 95% CI 0.75–0.92, p-value < 0.001; Q4: OR 0.74, 95% CI 0.67–0.83, p-value < 0.001), and the same result could also be obtained in the full model (Q3: OR 0.76, 95% CI 0.68–0.86, p-value < 0.001; Q4: OR 0.77, 95% CI 0.68–0.87, p-value < 0.001). A sensitivity analysis was also conducted on the cohort before applying

Table 2 Logistic regression analysis models showing the associations between LC9 score and BPH

Variables	Model1		Model2		Model3	
	OR (95%CI)	*P*	OR (95%CI)	*P*	OR (95%CI)	*P*
LC9 score	0.99 (0.99, 1.00)	< 0.001	0.99 (0.98, 0.99)	< 0.001	0.99 (0.99, 0.99)	< 0.001
LC9 score Quantiles						
Q1	Reference		Reference		Reference	
Q2	0.92 (0.83, 1.02)	0.131	0.79 (0.71, 0.88)	< 0.001	0.80 (0.72, 0.89)	< 0.001
Q3	0.83 (0.75, 0.92)	< 0.001	0.75 (0.67, 0.84)	< 0.001	0.76 (0.68, 0.86)	< 0.001
Q4	0.74 (0.67, 0.83)	< 0.001	0.76 (0.67, 0.86)	< 0.001	0.77 (0.68, 0.87)	< 0.001

Model 1: unadjusted

Model 2: adjusted for age, ethnicity, education, Townsend Deprivation Index and the BMI

Model 3: Additionally, adjusted for alcohol use status and the medical history of hypertension, diabetes and CVD

LC9, life's crucial 9 score

Table 3 Logistic regression analysis models showing the associations between LC9 score and PCa

Variables	Model1		Model2		Model3	
	OR (95%CI)	*P*	OR (95%CI)	*P*	OR (95%CI)	*P*
LC9 score	1.00 (1.00, 1.01)	0.373	1.00 (0.99, 1.00)	0.429	1.00 (0.99, 1.00)	0.226
LC9 score Quantiles						
Q1	Reference		Reference		Reference	
Q2	1.07 (0.92, 1.24)	0.382	0.92 (0.79, 1.07)	0.268	0.90 (0.77, 1.05)	0.181
Q3	1.18 (1.02, 1.37)	0.028	1.04 (0.89, 1.22)	0.628	1.02 (0.87, 1.19)	0.846
Q4	1.00 (0.86, 1.17)	0.999	0.96 (0.81, 1.14)	0.670	0.94 (0.79, 1.12)	0.487

Model 1: unadjusted

Model 2: adjusted for age, ethnicity, education, Townsend Deprivation Index and the BMI

Model 3: Additionally, adjusted for alcohol use status and the medical history of hypertension, diabetes and CVD

LC9, life's crucial 9 score

covariate-based exclusions. The findings remained stable, confirming the robustness of the results despite the data exclusion (see Supplementary File 1: Table S5).

The relationship between the LC9 score and PCa

Table 3 summarises the outcomes of logistic regressions between LC9 score and PCa occurrence. When considering the LC9 score as a continuous factor, model 1 (the unadjusted model) showed no significant association between LC9 score and PCa (OR 1.00, 95%CI 1.00-1.01, $p > 0.05$), this result was consistent with the findings from the other two models. Even in the sensitivity analysis, compared relative to LC9 quartile 1, the odds of PCa for individuals in the third or fourth quartile of LC9 score were not statistically significant in all models (all $p > 0.05$). Moreover, we conducted a sensitivity analysis using the cohort before covariate exclusion and the results remained consistent with those obtained after exclusion (see Supplementary File 1: Table S6).

RCS analysis of the LC9 score with prostate diseases

RCS analyses revealed an inverse linear association between the LC9 score and the risk of BPH, with a notable inflection point identified at a score of 72.5 (Fig. 2A). In contrast, while a slight upward trend in LC9 scores was observed, no significant overall or non-linear association was found between LC9 score and the risk of PCa (Fig. 2B).

Subgroup analysis

Table 4 describes the subgroup analysis of this study, revealing the relationship between LC9 score and the occurrence of BPH across different factors, including age category, ethnicity, Townsend Deprivation Index, education level, BMI category, alcohol use, hypertension history, diabetes history and CVD history. Table 4 showed that except for Townsend Deprivation Index, no interaction was found with other covariates (p for interaction > 0.05). In those with lower Townsend Deprivation Index, the association between LC9 score and the risk of preventing BPH was more substantial. Although Table S3 showed variations in population settings (subgroups), we did not observe a substantial association between LC9 score and PCa, indicating a minimal likelihood of heterogeneities (p for interaction > 0.05).

Discussion

This study investigated the association between the LC9 score and prostate diseases in individuals from the UK Biobank. The findings reveal a substantial association, indicating that higher LC9 scores are linked with lower risk of BPH. However, no association was discovered between the LC9 score and PCa in either continuous or

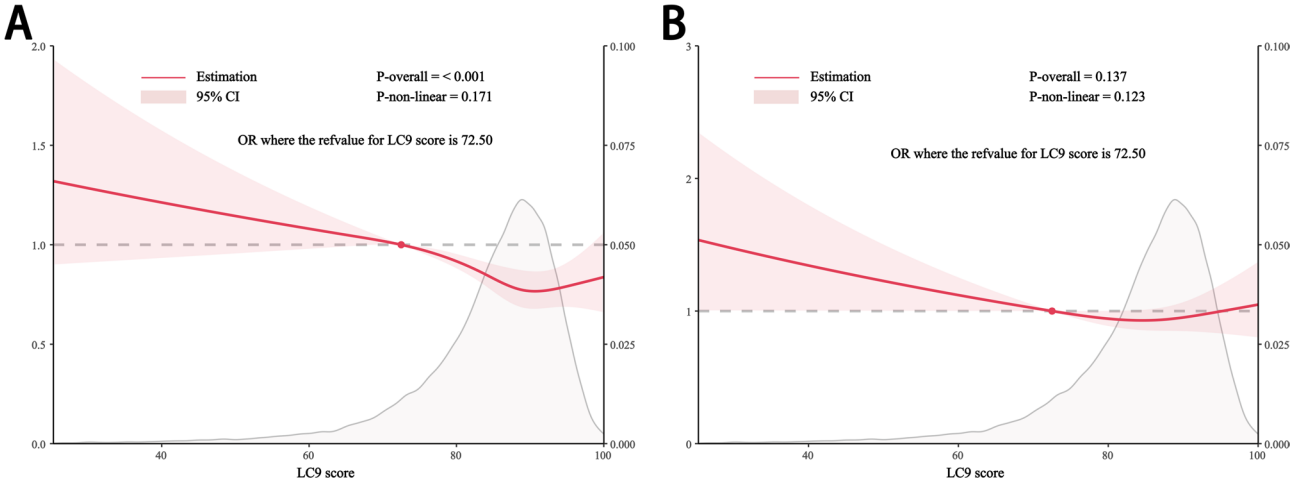

Fig. 2 **A**. Association between LC9 score and BPH visualised by restricted cubic splines. **B**. Association between LC9 score and PCa visualised by restricted cubic splines

categorical models, suggesting that the impact of cardiovascular health on PCa remains unclear.

A variety of factors can lead to BPH, including hormonal levels, environmental factors, genetic predisposition and psychological factors [19, 20, 21, 22]. Growing evidence suggests that the role of aging and chronic inflammatory stimulation are particularly important in the initiation and progression of prostate hyperplasia, as well as in the progression of symptoms [23, 24]. While numerous research studies have examined the correlation between cardiovascular health and aging, starting with LS7 and later LE8, both of which have consistently shown similar findings [25, 26, 27], few studies have specifically addressed the connection between cardiovascular health and BPH. Since the association between depression and BPH symptoms has been established by several prior studies [28, 21, 29], LE8's failure to assess depression may limit its ability to fully capture an individual's health behaviors and characteristics compared to LC9[35]. By including depression, LC9 offers a more comprehensive reflection of both physiological and behavioral health, as well as their relationship with BPH.

In our study, we found a significant inverse association between the LC9 score and the risk of BPH. Participants in the highest LC9 quartile (Q4) exhibited a 26% lower odds of BPH compared to those in the lowest quartile (Q1). This association persisted after full adjustment for potential confounders, with a 23% reduced risk observed in Q4 relative to Q1. In the restricted cubic spline (RCS) analysis, a significant inverse association was found between LC9 score and the risk of benign prostatic hyperplasia (BPH), with the inflection point occurring at an LC9 score of 72.5. When the LC9 score is below 72.5, the risk of BPH decreases significantly as the LC9 score increases. However, when the LC9 score exceeds 72.5, the decline in risk levels off. This may be due to the fact that, in individuals with higher LC9 scores, cardiovascular and psychological health are already in a better state, making further improvements less likely to result in significant risk reduction. These findings suggest that maintaining a higher LC9 score—through healthy dietary changes, regular physical activity, and improvements in psychological well-being—may help prevent the development of BPH. For individuals with lower LC9 scores, early evaluation of prostate volume and urinary flow rate may be warranted.

The possible mechanisms include that individuals with lower LC9 score may accelerate the aging process, while increasing the risk of cardiovascular and chronic diseases, such as hypertension and diabetes, which is consistent with our findings [30, 31]. Other mechanisms may include that lower LC9 scores lead to systemic chronic inflammation and place various organs under a state of high oxidative stress. This increase in immune cell infiltration in prostate tissue can lead to tissue remodeling through the action of various cytokines, ultimately resulting in the occurrence of prostate hyperplasia [32, 33]. A large prospective biomarker-based study highlights that high-density lipoprotein (HDL) cholesterol and apolipoprotein A are significant protective factors against the development of BPH, while low LC9 implies higher BMI and abnormal lipid metabolism, which may be another possible mechanism [34, 32]. In addition, subgroup analysis revealed that the LC9 score appeared to have a stronger protective effect against BPH among individuals with a lower Townsend Deprivation Index. A similar pattern has been observed in studies reporting that rural elderly with prostate cancer is associated with higher risks of cardiovascular disease, prostate cancer-specific mortality, and all-cause mortality compared to metropolitan and urban populations [35]. These findings highlight the critical role of healthcare accessibility, quality of services, psychosocial stress, and living environment in shaping

Table 4 Subgroup analysis between LC9 score and BPH. All presented covariates were adjusted (as in model 3) except the stratification variable itself

Variable	Count	Percent	OR	Lower	Upper	*P* value	*P* for interaction
Agegroup							0.882
60 or above	10,290	40.1	0.992	0.986	0.998	0.01	
less than 60	15,366	59.9	0.994	0.988	1.001	0.075	
Race							0.483
ASIAN OR ASIAN BRITSH	241	0.9	1.002	0.951	1.056	0.933	
BLACK OR BLACK BRITSH	124	0.5	0.995	0.916	1.08	0.896	
CHINESE	31	0.1	-	-	-	-	
MIXED	90	0.4	1.026	0.94	1.119	0.569	
Other ethnic group	114	0.4	1.052	0.975	1.135	0.191	
WHITE	25,056	97.7	0.993	0.989	0.997	0.001	
Tdigroup							0.015
Q1	8505	33.2	0.983	0.976	0.991	< 0.001	
Q2	8447	32.9	0.998	0.99	1.006	0.603	
Q3	8704	33.9	0.996	0.989	1.003	0.251	
Edu							0.141
college or above	13,370	52.1	0.989	0.983	0.996	0.001	
high school	3479	13.6	1.003	0.99	1.015	0.659	
less than high school	8807	34.3	0.994	0.987	1	0.067	
Bmigroup							0.699
low	39	0.2	-	-	-	-	
normal	4751	18.5	0.996	0.984	1.007	0.461	
obesity	5074	19.8	0.996	0.988	1.004	0.332	
overweight	15,792	61.6	0.99	0.985	0.996	0.001	
Alco							0.181
Current	24,721	96.4	0.993	0.988	0.997	0.001	
Never	384	1.5	0.982	0.953	1.012	0.229	
Previous	551	2.1	1.003	0.984	1.023	0.738	
HBP							0.882
No	19,269	75.1	0.993	0.987	0.998	0.006	
Yes	6387	24.9	0.994	0.987	1.001	0.107	
DM							0.781
No	24,537	95.6	0.993	0.989	0.998	0.003	
Yes	1119	4.4	0.99	0.976	1.004	0.152	
CVD							0.696
No	24,316	94.8	0.993	0.988	0.997	0.002	
Yes	1340	5.2	0.996	0.982	1.01	0.54	

the association between cardiovascular health and prostate diseases.

Previous research on prostate and cardiovascular health has primarily focused on the cardiotoxicity associated with prostate cancer treatments [36]. For instance, chemotherapy for prostate cancer carries inherent cardiovascular risks [37]. Additionally, the cardiovascular safety profile of gonadotropin-releasing hormone (GnRH) antagonists versus agonists remains controversial. While different androgen deprivation therapies exhibit varying cardiovascular outcomes, current evidence does not conclusively favor one approach over the other based solely on cardiovascular risk [38]. Therefore, maintaining optimal cardiovascular health is undoubtedly beneficial for prostate cancer patients. Additionally, several studies have investigated the relationship between oxidative stress and prostate cancer, with findings often contradictory due to variations in the specific oxides and antioxidants considered [39, 40, 41]. This suggests that assessing the overall potential factors, rather than focusing on individual elements in isolation, may provide a more effective and meaningful understanding.

However, despite the known associations of cardiovascular health with aging, mental health, and oxidative stress [42, 43, 44], our study did not find any significant association between the LC9 score and prostate cancer. This observation may be due to our assumption that various lifestyle factors have a direct association with prostate cancer, without considering the duration of exposure to such lifestyles. For instance, a patient who experienced

a sudden, significant life event leading to drastic lifestyle changes shortly before the survey may not reflect the long-term impact of their prior lifestyle. Additionally, in the subgroup analysis of LC9 score and PCa, an interaction was observed among BMI subgroups. Specifically, the LC9 score demonstrated a protective effect against PCa in overweight individuals, who constituted the largest proportion of the study population (61.6%). Furthermore, consistent with the significantly lower prevalence of PCa compared to benign prostatic hyperplasia (BPH), our study also identified a protective role of LC9 in benign conditions. It is possible that the absence of a similar association in malignant conditions, such as PCa, may be attributed to the limited sample size, which could hinder the detection of such distinctions.

Our study has several strengths. First, we utilized the updated LC9 index, which highlights the role of psychological factors in aging. Second, by drawing on the UK Biobank cohorts, we substantially increased sample size and strengthened the reliability of our findings. However, this study also has some limitations. First, as a cross-sectional study, it cannot establish causality. Second, limitations inherent to the UK Biobank dataset should be acknowledged. Baseline heterogeneity across LC9 quartiles may lead to residual confounding despite adjustments, and reliance on self-reported questionnaires could introduce potential bias. As for certain subgroup or stratified analyses, the relatively smaller sample sizes may have limited the ability to detect weaker associations. Third, in calculating the LC9 score, a more detailed assessment of the weight assigned to the depression score could enhance the accuracy of the LC9 score. In addition, while leveraging large-scale open datasets, data privacy considerations remain essential. Recent research has graded sensitive data and suggest ethical standards for privacy protection based on varying levels of data sensitivity, enabling responsible data sharing while upholding ethical principles [45]. Future research should incorporate prospective cohort studies or longitudinal designs that explore underlying mechanistic pathways and include more diverse population samples to establish causal inferences.

Conclusion

In conclusion, our study demonstrates a significant negative association between overall cardiovascular health, as measured by the LC9 score, and the risk of BPH. These findings underscore the potential relevance of both lifestyle and psychological factors in the development of BPH. While the exact mechanisms remain unclear, our results suggest that routine cardiovascular screening might help identify individuals at higher risk, particularly those with lower LC9 scores. While no significant association between the LC9 score and the occurrence of PCa, the lack of a clear link warrants further investigation. The complex etiology of PCa suggests that additional research is needed to clarify whether cardiovascular health plays a role in its development.

Supplementary Information

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Supplementary Material 1

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Author contributions

H.W. and R.T. contributed to the concept and design, and drafted the manuscript. J.W. was responsible for the acquisition, analysis, and interpretation of data, as well as the statistical analysis. J.L. and S.L. critically reviewed the manuscript for important intellectual content. M.L. and H.H. provided administrative, technical, or material support. M.L. and J.L. supervised the study. J.W. had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors reviewed the manuscript.

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Data availability

UK Biobank data are available through application to the database https://www.ukbiobank.ac.uk/. Restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of UK Biobank.

Declarations

Ethics approval and consent to participate

The ethical approval for the UK Biobank research was granted by the North West Multicenter Research Ethical Committee, and written informed consent was obtained from all the participants during the baseline recruitment to the UK Biobank. This current study was specifically approved by the UK Biobank under application number 332912.

Consent for publication

The authors consent to the publication of the submitted manuscript.

Competing interests

The authors declare no competing interests.

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