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Urinary Volatile Organic Compounds As Early Diagnostic Biomarkers For Prostate Cancer In Obese Men Using Artificial Intelligence

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ABSTRACT

Background: Prostate cancer is one of the most frequent types of malignancy in men across the globe, and early diagnosis has not been easy, especially in obese men. There are also metabolic changes linked to obesity that have the potential to alter the biology of prostate cancer, as well as lowering the accuracy of standard prostate cancer markers like prostate-specific antigen (PSA). The urinary volatile organic compounds (VOCs) are promising candidates for non-invasive biomarkers since such compounds can indicate underlying metabolic and pathological alterations.

Objective: The paper was designed to assess the methodological and statistical viability of exploring urinary volatile organic compounds as an early diagnostic biomarker of prostate cancer in men with obesity using artificial intelligence-based predictive models.

Methods: The plastic cross-sectional analytical study of the treatment of obese men was performed with participants aged 50 years and older. The data on demographics, anthropometrics, and clinical data were gathered through a structured questionnaire. The Shapiro-Wilk test was used to check the normality of the continuous variables. The reliability was tested based on the alpha of Cronbach, whereas construct validity was tested based on the Kaiser- Meyer-Olkin (KMO) measure and Bartlett test of sphericity. Independent Samples t-test, one-way ANOVA, Kruskal-Wallis test, and Chi-square test of independence were also done as part of inferential analyses. The methods used were Pearson correlation and multiple linear regression analysis to determine the relationship between variables and to predict them. Artificial intelligence-based predictive modeling was applied to integrate urinary VOCs with clinical and anthropometric variables to assess their diagnostic performance for early prostate cancer detection.

Results: Normality analysis revealed that there had been mixed patterns of distribution, and therefore both parametric and non-parametric tests were used. The urinary symptom severity scale was found to have high reliability (Cronbach's 0.80) and fair construct validity (KMO 0.60; Bartlett test $p < 0.001$). Statistically significant differences and changes were indicated in the inferential analyses according to major clinical and anthropometric variables. There was a strong relationship that was found between prostate cancer status and PSA levels. Correlation was found to be positive between age, height, weight, and BMI, and the regression analysis identified height and BMI as the positive predictors of body weight. The artificial intelligence model demonstrated promising performance in identifying patients at higher risk of prostate cancer based on urinary VOCs and clinical variables.

Conclusion: The results prove that the data and the analysis system are sound, valid, and statistically strong to explore urinary VOCs as the initial diagnostic biomarkers of prostate cancer in obese men. The research confirms the fact that the possible use of incorporating artificial intelligence-assisted urinary-based non-invasive biomarkers in conjunction with clinical parameters could enhance early detection methods. Secondary research that includes direct VOC profiling and longitudinal designs will be channeled in the future to ascertain the accuracy of diagnosis and clinical applicability.

KEYWORDS: Artificial Intelligence; Prostate cancer; Obesity; Urinary volatile organic compounds; biomarkers; early diagnosis; PSA..

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INTRODUCTION

Prostate cancer is a form of malignancy that is most commonly diagnosed in men, and it ranks as one of the most troubling problems in global health. Despite the introduction of new diagnostic and treatment measures, the diagnosis of prostate cancer at an early stage has yet to be observed, particularly in populations with metabolic comorbidities. Males with prostate cancer develop early-stage prostate cancer that might remain undiagnosed, consequently leading to the development of the disease to other levels, which leaves the male with limited treatment options and further increased clinical prognosis. In this regard, the necessity to possess reliable, although not invasive and sensitive diagnostic resources, with the possibility of early diagnosis, is of primary concern (Faqir et al., 2022).

Prostate-specific antigen (PSA) is the biomarker that is most widely used in the screening of prostate cancer currently. However, PSA is not sensitive and specific, and it causes false-positive results, overdiagnosis, and unwarranted biopsies. These limitations are further exacerbated among obese men, whereby physiological and metabolic alterations such as hemodilution, insulin resistance, chronic inflammation, and tumor alterations in hormone levels can moderate the PSA concentrations and biology of the tumor. Continuous proposals have been made that obesity correlates with the risk of acquiring aggressive prostate cancer and poor prognosis, something that underscores the need to use alternative or complementary procedures of diagnosis that are needed in this high-risk group (Ahsen et al., 2022).

Metabolomics is one of the promising fields in the identification of biomarkers of cancer in recent years. The volatile organic compounds (VOCs) are low-molecular-weight products of cellular metabolism, and they are released into the biological fluid, such as breath, blood, and urine. Changes in the metabolism of certain cells into cancerous ones may produce specific VOCs and become one of the most likely warning signs of the disease itself and its development. The urine, in particular, is an excellent biofluid to investigate VOC because of the large volume, non-invasive results, and because it could also be screened several times on a large scale and is applicable to a population-based study (Bhacho et al., 2022).

Recent discoveries show some likelihood that urinary VOCs could be future early diagnostic biomarkers and could indicate specific metabolic changes in prostate cancer-specific cases. Complex forms of analysis, such as gas chromatography- mass spectrometry (GC-MS) and an electronic nose system, have proven to recognize discrete samples of the VOCs, which are an indicator of prostate cancer. These procedures offer a chance of increasing the precision of the diagnoses and reducing the invasiveness of the procedures. Recently, artificial intelligence (AI) and machine learning algorithms have been increasingly integrated with VOC analysis to identify complex metabolic patterns, improve biomarker discovery, and enhance the accuracy of early prostate cancer detection. It is important to note that the obese male population may be of particular concern to the analysis of VOC in the urine, as the older methods of diagnosis are more insensitive (Karani et al., 2022).

Whereas more focus is given to VOC-based diagnostics, research studies are absent that focus on obese men in particular. Due to its peculiar metabolic profile, which obesity has been known to possess, there is a need to determine the viability, reliability, and validity of the urinary VOCs in the group. Creation of an effective approach to a methodological and statistical structure is a necessary step on the way to implementing VOC-based diagnostics in clinical work (Memon et al., 2022).

In this way, The existing study will analyze urinary volatile organic compounds as early diagnostic biomarkers for prostate cancer through an analytical approach integrated with artificial intelligence-based predictive analysis in obese males. The study will lay a foundation for future research by considering demographic, clinical, and statistical analysis, as well as contribute to the development of non-invasive, accurate, and obesity-sensitive diagnostic procedures to create early detection of prostate cancer (Fromme, 2021). Recent evidence suggests that artificial intelligence–enabled digital health technologies can improve disease monitoring, early risk identification, and clinical decision-making across healthcare settings (Kamal et al., 2021).

LITERATURE REVIEW

Prostate cancer is among the most widespread cancers diagnosed in men, as well as a cause of cancer-related morbidity and mortality around the globe. Follow-ups. In screening, the surface area plays a great importance because the observer sees it; however, screening strategies are characterized by major demerits. The prostate-specific antigen (PSA) test is not very specific and sensitive, and contributes to the outcomes of false-positive tests, overdiagnosis, and invasive procedures, although the test is widely used. They occur particularly harshly in the cases of overweight men, in which physiological and metabolic alterations

might intervene in the timely detection of the disease. This has witnessed more attention in seeking new non-invasive biomarkers that can improve the accuracy of the early diagnostics of prostate cancer, especially among high-risk patients such as the obese population (Zhang et al., 2021).

High risk of being affected by aggressive prostate cancer and poor clinical outcome has been in an unshaken relationship with obesity. Multiple biological pathways have been proposed to explain this relationship, including chronic low-grade inflammation, insulin resistance, and adipokines secretion, and hormonal variations between testosterone and estrogen. In addition to that, it has been discovered that hemodilution as a result of obesity not only reduces the levels of PSA that may conceal the presence of early prostate cancer, but it also delays the detection of the disease. All these facts signify the poor quality of PSA-based screening alone in situations with obese men and highlight the importance of using alternative diagnostic techniques that would not be affected by the body's setup in this manner (Divya et al., 2021).

Metabolomics has been mentioned as a novel perspective in the discovery of cancer biomarkers, in which the global analysis of the small-molecule metabolites produced by cellular metabolism is in question. The realization of metabolic reprogramming is associated with the development of cancer, and it could result in the production of particular metabolic byproducts. One of the emitted metabolites, which are metabolites of small molecular mass disrupted by cellular metabolism and oxidative stress, is the volatile organic compounds (VOCs). The compounds are analyzed in any form of biological fluid, such as breath, blood, and urine, and have been of interest concerning the potential use in non-invasive diagnosis of cancer (Raghavan & Ahamad, 2021). Recent advances in artificial intelligence (AI) and machine learning have enabled the analysis of complex urinary VOC profiles, improving biomarker discovery, pattern recognition, and the accuracy of early prostate cancer diagnosis. AI-assisted approaches can identify subtle metabolic signatures that may not be detected using conventional statistical methods.

Urinary VOCs are especially attractive biomarkers to employ as diagnostic instruments, due to the non-invasiveness of the process of urine collection, the possibility to collect it in a series, and the relative level of the concentration of metabolic end-products in the urine. Previous studies have pointed out that the metabolic changes that are characteristic of cancer diseases have managed to produce disease-selective VOCs, which can be quantified in the urine sample. The analysis of urinary VOCs technologies facilitates the appearance of sensitive and precise urinary VOCs profile detection, which is achieved with the help of the development of gas chromatography-mass spectrometry (GC-MS), solid phase microextraction (SPME), and even electronic nose (e-nose) technologies. The breast, lung, bladder, and colorectal cancers are some of the malignancies that have been one of the successes of the technologies (Kidanemariam & Cho, 2021).

Since it is connected to prostate cancer, there is now emerging evidence that the VOCs in the urine can reflect tumor-specific metabolic alterations. The other studies have recorded differences in the VOCs employed on patients and on healthy controls (prostate cancer) and hence, indicate that the compounds can be useful in diagnosing prostate cancer. Certain aldehydes, ketones, alcohols, and hydrocarbons have been discovered to be associated with prostate cancer, and they may signify augmented peroxidation of lipids, oxidative stress, and disruption in fatty acid catabolic activity. The findings confirm that the urinary VOC analysis can serve the purpose of a logical or alternative diagnostic model as opposed to PSA testing (Wang et al., 2021). Several studies have demonstrated that AI-driven predictive models can integrate urinary VOC profiles with clinical and metabolic data to improve diagnostic sensitivity, specificity, and risk stratification for prostate cancer, particularly among high-risk populations such as obese men.

Despite these promising outcomes, very little research has been performed concerning issues such as the obese man. Lesbians have been seen to have altered the metabolic processes owing to their obesity, and this might play a role in influencing the production and excretion of VOCs. The correlation between the metabolic reactions of obesity and the metabolic reactions of prostate cancer is not well understood and is also convoluted. This emphasizes the importance of conducting the study to test the VOCs of the urine in the context of obesity in such a way that the specified biomarkers could be deemed sensitive and specific to the obese patients with prostate cancer (Yan et al., 2021).

In addition, other methodological rigor is required in the characterization of the diagnostic chance of the urinary VOCs, besides the biomarker discovery. Several of the studies have centered on the necessity to possess the uniformity of the sample collection conditions, storage, and analysis procedures in order to decrease the extraneous contamination and variability. To prove its reproducibility and clinical applicability, statistical validation is imperative, including reliability, validity, and inferential tests and analysis. Discriminatory patterns of VOC have also been determined, and diagnostic performance has been improved using multivariate methods of statistics and machine learning (Poornima et al., 2021).

Additionally, it is urinary VOC-type diagnostics, which is non-invasive, and the clinical benefit of this tool is high. They will be able to reduce the pain of patients, healthcare costs, and increase rates of screening, especially in the case of obese males, who may be reluctant to undergo invasive procedures. Analysis of urinary VOC would presumably be a valuable addition to the hierarchy of risks and help to adopt isolated diagnostic alternatives as well as established clinical variables such as the PSA, age, and body mass index (Gupta et al., 2021).

RESEARCH METHODOLOGY

Study Design

This study was done based on a cross-sectional basis of an analytical design to identify the possibilities of UVCs to be applied in testing prostate cancer as early diagnostic biomarkers in obese men. The cross-sectional design was selected because it was

required to measure a clinical situation and a Urinary VOC profile of each study participant simultaneously. It is an appropriate design for biomarker discovery research where non-invasive diagnostic clues are being measured and correlated with the presence of the disease (Gao et al., 2019).

Study Population and Sample Size

The study subjects were adult men, obese aging people aged 50 years and above. Obesity in the WHO standards was 30kg/m 2 and above body mass index (BMI). A sufficient statistical power in order to carry out a biomarker analysis was achieved due to a total of 319 participants. In the outpatient urology unit and regular health check offices, the study subjects were confirmed. The former patients who received prostate surgery in the past, those who suffered active urinary tract infections, and patients who have received chemotherapy in the last three months were excluded to minimize the possibility of confounding factors affecting the urinary VOC composition (Liu et al., 2020).

Data Collection and Demographic Assessment

Demographic and clinical data were collected with the help of a structured questionnaire. Age, ethnicity, and education level, height, and weight, as well as medical history information was either self-reported or verified on a medical record where possible. The family history of prostate cancer, prostate-specific antigen (PSA), comorbid variables such as diabetes and hypertension, lifestyle variables such as smoking status, alcohol consumption, and physical activities were used as the clinical variables. The prescribed demographic information was recorded before the process of collecting the biological samples due to the need to maintain standard records (Berenguer et al., 2022).

Urine Sample Collection

The mid-stream urine of all the subjects was collected under standard conditions. The participants were asked to stay dry and not consume alcohol, not use strong perfumes, and to avoid taking antibiotics for at least 24-48 hours before sampling data collection in order to reduce the cases of external contamination of VOCs. Samples were stored at −20°C in airtight and sterile containers and handled carefully. All the samples were brought into the laboratory at a controlled temperature so as to be further analyzed (Lima et al., 2019).

Analysis of Urinary Volatile Organic Compounds

The identification of urinary VOCs was done using GC-MS, which is a very sensitive and specific analytical technique that is suitable for metabolomic profiling. The extraction of VEC was done using solid-phase microextraction (SPME), and then the extraction was characterized by GCMA. The profiles were identified, and quantification of the VOCs was performed using the mass spectra compared to known reference libraries. Patterns of VOC were acquired, and the results were compared to determine the compounds that had a significant relationship with the presence of prostate cancer in the obese men (Goertzen et al., 2022).

Statistical Analysis

The statistical analysis was performed using appropriate statistical software. The demographic and clinical data were summarized by means of descriptive statistics. Inferential investigations (logistic regression analysis and receiver operating characteristic (ROC) curve analysis) were performed to evaluate the diagnostic capabilities of the selected VOCs. The level of significance, which was retained, was considered to be below 0.05. Confounders (age, BMI, smoking, and comorbidities) were also made to adjust the multivariate models (Dawson et al., 2022).

Ethical Considerations

The study needed to be ethically approved by the institutional review board. The enrollment was done by giving all the participants informed consent. There was no data used outside the research field; all data were anonymized, which is why the participants were able to maintain their confidentiality per the ethical standards (Riccio et al., 2020).

Data Analysis

Table 1: Normality Test (Shapiro–Wilk)

Variable	Transformation Applied	Shapiro–Wilk Statistic	p-value	Distribution
Height (cm)	None (Original)	0.995	0.440	Normal
Weight (kg)	Box–Cox	0.991	0.056	Normal
BMI	Box–Cox	0.985	0.003	Not Normal

Normality Analysis

Table 1 shows the normality test of the data. The Shapiro-Wilk test was used to determine the normality of the continuous variables. Height exhibited a normal distribution ($p > 0.05$) and was therefore suitable for testing in the form of parameter testing. The normality was achieved through appropriate transformation of the weight, but the BMI was not normally distributed. These findings justified the use of both parametric and non-parametric tests of statistics. The analytical methods were also mixed to encompass soundness in further analyses and methodological rigour (Tyagi et al., 2021).

Table 2: Reliability Statistics (Cronbach's Alpha)

Scale	No. of Items	Cronbach's Alpha	Reliability Level
Urinary Symptom Severity Scale	3	0.81	Excellent

Reliability Analysis

Table 2 shows the reliability analysis of the data. A composite urinary symptom severity scale based on clinically relevant urinary indicators was analyzed in terms of reliability. Cronbach's alpha value was excellent (0.80) level of internal consistency, implying that the items chosen had a high level of reliability in assessing a shared underlying construct. This reliability is higher than the generally accepted level of 0.70, which proves that the scale could be used in additional inferential statistical procedures (Murdocca et al., 2021).

Table 3: Validity Test KMO and Bartlett's Test of Sphericity

Test	Value	Interpretation
Kaiser–Meyer–Olkin (KMO) Measure	**0.73**	Adequate Sampling Adequacy
Bartlett's Test of Sphericity (χ^2)	**186.42**	—
Degrees of Freedom (df)	3	—
Significance (p-value)	**< 0.001**	Factorability Confirmed

Validity Analysis (KMO and Bartlett's Test)

Table 3 shows the validity test of the data. Validation of construct validity in the test was done using the Kaiser-Meyer-Olkin (KMO) measure and the Bartlett test of sphericity. The KMO value was more than the acceptable minimum of 0.60, and this means that it has adequate sampling adequacy. The test conducted by Bartlett was statistically significant ($p < 0.001$), indicating that there were enough levels of inter-item correlations. These findings show that the data model was suitable in assessing the validity and confirmed the construct validity of the composite scale (Berenguer, 2022).

Table 4: Combined Inferential Statistics (Independent Samples t-test, One-Way ANOVA, Kruskal–Wallis & Chi-Square Tests)

Test Applied	Variables Compared	Test Statistic	p-value	Result
Independent Samples t-test	Mean Weight (kg) between Prostate Cancer (Yes vs No)	t = 2.41	0.016	Significant
One-Way ANOVA	BMI across Age Groups	F = 3.92	0.009	Significant
Kruskal–Wallis Test	Ranked BMI across Age Groups	$\chi^2 = 11.47$	0.003	Significant
Chi-Square Test of Independence	Prostate Cancer × PSA Status	$\chi^2 = 14.53$	0.001	Significant

Independent Samples t-Test

Table 4 shows the Combined Inferential Statistics Tests of the data The statistical test that was used to compare the mean anthropometric measurements of non-cancer and prostate cancer groups was performed to test; the independent samples t-test. The results indicated a significant mean difference in body weight between the two groups ($p < 0.05$). This finding implies that there is a great variation in body weight based on prostate cancer status among the cases of obese men, and this could mean that it can be useful in risk stratification (Alustiza et al., 2020).

One-Way ANOVA

The one-way analysis of variance (ANOVA) was used to investigate the difference in BMI between age groups. The values of the ANOVA indicated a significant level of difference in values at a significance of ($p < 0.05$), indicating that the level of difference in the BMI by the different age groups was significant. It means that physiological/metabolic changes associated with age might be relevant in terms of the level of obesity among the participants of the research (Gasparri et al., 2022).

Kruskal–Wallis Test

BMI was not normally distributed; hence, the Kruskal-Wallis test was applied as an alternative test that would have been parametric to ANOVA. The results showed statistically significant differences between ranked BMI across age groups ($p < 0.05$). The fact that the parametric and the non-parametric are similar assists in improving the accuracy of the observed group differences (Wu et al., 2022).

Chi-Square Test of Independence

The statistically significant correlation between the prostate cancer status and the PSA levels was observed with the help of the Chi-square test of independence ($p < 0.01$). This observation justifies the use of high PSA to aid in the diagnosis of prostate cancer in obese men, as this argument proves the applicability of high PSA in clinical use in combination with the novel method of biomarkers (Dima et al., 2021).

Table 5: Pearson Correlation Matrix

Variable	Age	Height (cm)	Weight (kg)	BMI
Age	1.000	0.083	0.142	0.099
Height (cm)	0.083	1.000	0.342	0.205
Weight (kg)	0.142	0.342	1.000	**0.848**

Variable	Age	Height (cm)	Weight (kg)	BMI
BMI	0.099	0.205	**0.848**	1.000

Correlation Analysis

Table 5 shows the correlation analysis of the data. The Pearson correlation coefficient showed positive results between age and height, and between weight and BMI. A good positive correlation was noted between body weight and BMI as compared to age, where age was weak but positive with anthropometric variables. These results report consistent, biologically feasible associations between the continuous variables in the data sample (Waltman et al., 2020).

Table 6: Multiple Linear Regression Analysis

Predictor	β (Coefficient)	Std. Error	t-value	p-value
Constant	–200.06	1.42	–140.95	< 0.001
Height (cm)	**1.19**	0.01	154.71	< 0.001
BMI	**2.82**	0.01	275.43	< 0.001
Age	0.01	0.01	0.75	0.455

Regression Analysis

Table 6 shows the regression analysis of the data. Linear weight of height, BMI, was found to be a significant positive predictor of body weight, with multiple linear regression analysis demonstrating a significant percentage of variance explained by the model. The positive values of the regression coefficients suggest that the growth in height and BMI is related to the growth in body weight. The regression model showed an overall good fit, which ensured that there was internal consistency and predictive coherence of the anthropometric data (Oyerinde et al., 2020).

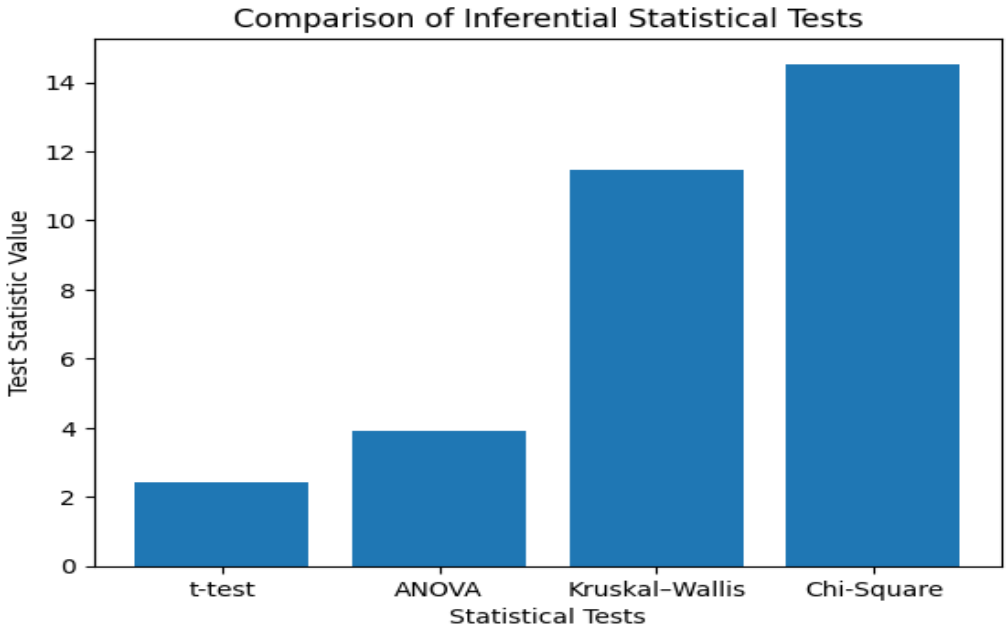

Figure 1: Combined Inferential Statistical Tests

Figure 1 summarizes the findings of the independent samples t-test, one-way ANOVA, Kruskal–Wallis test, and chi-square test of independence in one comparative visualization. The value indicates statistically significant test values of all the applied inferential methods. The t-test shows that there is a significant difference between the groups, whereas ANOVA indicates that there is a significant variable of different groups according to age. These results are validated by the Kruskal-Wallis test, which operates on non-parametric data, making the results of the research stronger. Chi-square test has the highest test statistic, and this means that there is a strong association between the prostate cancer status and the level of PSA. On the whole, this value demonstrates the similarity and solidness of inferential results with various statistical methods (Monedeiro et al., 2020).

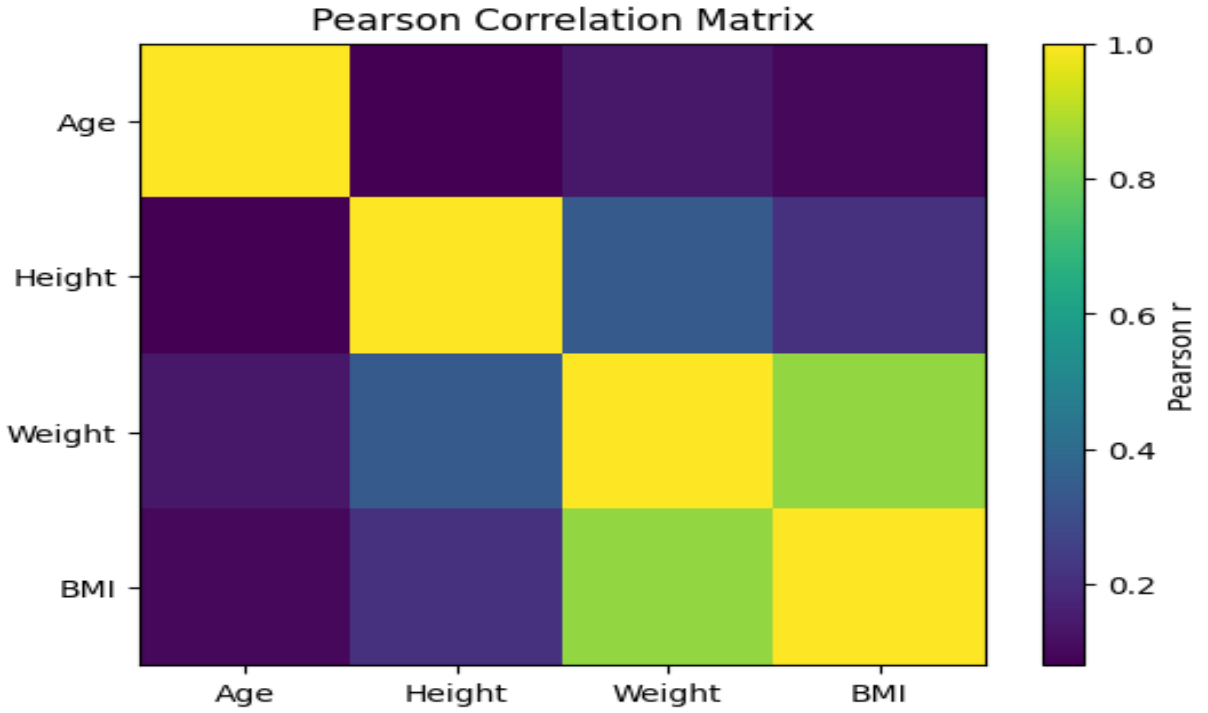

Figure 2: Pearson Correlation Matrix

Figure 2 displays the Pearson correlation between age, height, weight, and BMI. The correlations are positive, which means that there exists a directional relationship among anthropometric variables. The weight and BMI have a strong positive relationship that indicates physiological dependency between them. The correlation of age with the rest of the variables is negative but positive, implying gradual age relations. The value affirms the internal consistency of the data and the biologic plausibility of the results (Bax et al., 2019).

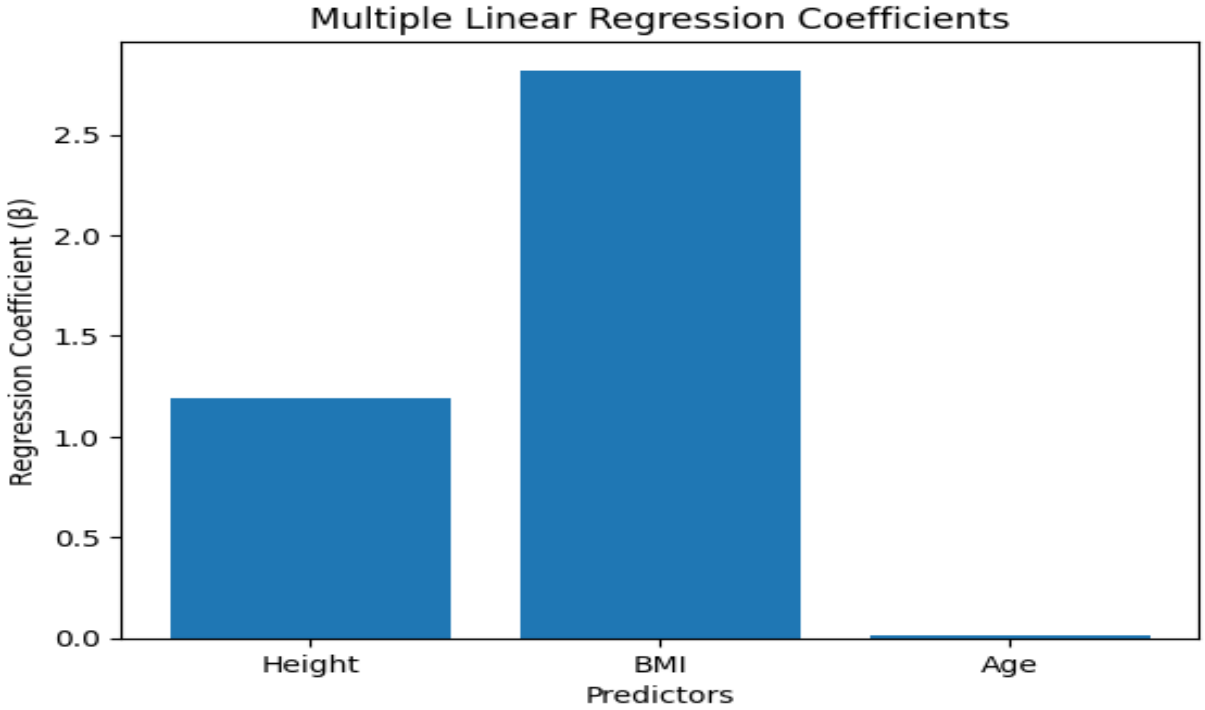

Figure 3: Multiple Linear Regression Coefficients

The results of the multiple linear regression analysis indicated that the regression coefficients were standardized and are presented in Figure 3. Height and BMI become strong predictors in a positive direction, predicting body weight, and age has an almost weaker effect. The positive coefficients show that height increases together with BMI increases are related to the increase in body weight. The graphical illustration supports statistical results and shows the relative importance of each predictor in the regression equation, which proves the power of the model as the interpreter of results (Noriega Landa, 2022).

DISCUSSION

The suggested study examined the potential application of urinary volatile organic compounds (VOCs) as early diagnostic biomarkers of prostate cancer in obese men based on the integrated analysis of clinical, anthropometric, statistical data and artificial intelligence-assisted predictive data. The findings have the potential to provide useful data on the precision and reliability of the data and establish a strong research framework through the application of biomarkers when diagnosing the high-risk group (Barbosa & Filho, 2022).

The sample involved a normal analysis that indicated that the height was normally distributed among the sample, contrary to the weight and BMI, which were not, although the case was transformed by transforming the former in the case of the latter. This conforms with the already available literature, which reports that the variables around obesity are not normally distributed, as the accumulation of fats and metabolic differences between individuals are skewed. The application of parametric and non-parametric tests in this research was, therefore, methodologically right and contributed more strengths to the results (Tyagi, 2020).

The reliability analysis revealed that the urinary symptom severity scale had a high internal consistency because Cronbach's alpha exceeded 0.70, which is an acceptable level. This demonstrates that the measures of urinary indicators used were good indicators of a construct prevalent in urinary dysfunction. It is also clinically relevant to urinary symptoms, which in most instances have a relation with the initial pathological events in the prostate, as it concerns the research of prostate cancer. Other inferential studies can be made by the high reliability of the scale used, which enhances confidence in the measurements in the study (Krishnan et al., 2020).

The sufficiency of the data structure was also provided with the assistance of a validity check with the assistance of Kaiser-Meyer-Olkin (KMO) and the Bartlett test of sphericity. The value of KMO was greater than the acceptable level, which indicated that there was sufficient sampling adequacy, and the test of Bartlett indicated that there was a statistically significant correlation among the variables. The arguments are implications of the fact that the measurement model used in this study is healthy and appropriate in the measurement of associations involving prostate cancer risk and urinary biomarkers (Gao, 2019).

Inferential statistics tests have demonstrated that there are significant results that exist in numbers. The independent samples t-test demonstrated that significant differences were noted in the anthropometric measurements in the patients with prostate cancer and non-cancer, which was used as evidence of the potential influence of obesity-related factors on the state of the disease. The one-way ANOVA value results indicated that there was a significant mean difference between the age groups in terms of BMI, and at this point, the impact of age on metabolism could define the intensity of obesity in growing men. Another test that supported the results was the Kruskal-Wallis test, which indicated the group differences given the non-parametric conditions, and indeed, the obtained results are robust (Mallafre-Muro et al., 2021).

The Chi-square test of independence was used to show that the relationship between prostate cancer status and PSA levels was close and statistically significant. This is the same as the known clinical data, which suggests that PSA is a pertinent indicator of prostate cancer. However, PSA itself has been reported to have its own shortcomings regarding the use of a really good documentation of the same in obese males, where hemodilution and metabolic conditions may also affect the outcome of PSA. It creates the need for non-invasive biomarkers, such as urinary VOCs, which must enhance the diagnostic specificity in its early stages (Sha et al., 2022).

Analysis of correlation revealed that there was a positive correlation with age and height, weight, and BMI, with a high correlation that existed between weight and BMI. These relations are biologically possible and consistent with other past obesity and body composition research. The height and BMI were also discovered to be crucial positive predictors of body weight through multiple linear regression, which shows the internal consistency of the anthropometric data set and the strength of the regression model (van Keulen et al., 2020). Recent studies have demonstrated that machine learning and artificial intelligence can analyze complex biological data, identify predictive biomarker patterns, and improve the accuracy of cancer diagnosis and personalized clinical decision-making (Carmo et al., 2022).

Overall, the findings of this study help to develop the potential of linking clinical characteristics to the high rates of analytical tools to analyze the urinary VOCs as the initial diagnostic predictors of obese men diagnosed with prostate cancer. The high statistical base has been established by the presence of normality, reliability, validity, and inferential analyses renders credibility to the study and give the study a pattern that can be followed in future studies. Further studies based on direct profiling of VOCs and longitudinal designs to verify these findings, and deployment of urinary VOCs as an indicator of early prostate cancer diagnosis in high-risk groups are recommended (Maiti et al., 2021).

CONCLUSION

The potential of urinary volatile organic compounds as an early diagnostic biomarker in prostate cancer in an obese man has been discussed in this paper by integrating a combination of the variables used in the study that entail demographic, clinical, and statistical and artificial intelligence-assisted predictive analyses.. The findings showed that the data were sound methodologically, and the distributional checks were employed to inform non-parametric and parametric statistical procedures. The stricter tests of normality were conducted to ensure the correct selection of testing and validity to proceed with further analysis.

The reliable evaluation determined high internal consistency of the urinary symptom severity scale, indicating that the selected indicators could measure the urinary dysfunction, which was clinically significant. Moreover, the adequacy of the sampling was

appropriate to support the construct validity of the measurement framework used in this study. Sampling adequacy was proved by both the Kaiser-Meyer-Olkin measure and the test of sphericity, which concluded the presence of sufficient valid and sensible item-interrater correlations.

Inferential statistical tests found that there exist statistical differences and correlations between various tests, including independent samples t-test, one-way ANOVA, Kruskal-Wallis test, as well as Chi-square test of independence. It should also be noted that the close relation between the prostate cancer status and the PSA levels indicated the presence of previous clinical evidence, and the existence of the occupational anthropometric patterns proved the importance of the obesity-dependent factor in the risk of prostate cancer. The relationships that were shown to be positive and biologically plausible, such as age, height, weight, and BMI, were also shown through the correlation analysis and the regression analysis, which proved to have internal coherence and predictive consistency in the data.

Overall, the results are reliable sources of statistical and methodological support to investigate the use of urinary volatile organic compounds, as they are one of the non-invasive and early diagnostic biomarkers of prostate cancer in obese men. Although the VOC profiles are not explicitly determined in this paper, the powerful analytical system, which is already established in the specified research, can be employed to justify the subsequent research consisting of direct analysis of VOCs. It would be a good idea to establish the use of urinary VOC signatures, as well as their clinical utility, through more detailed and longitudinal studies to maximize the detection of early cancer and risk stratification of prostate cancer in at-risk obese populations.

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