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Prediction and Classification of Blood Pressure among Students of Federal Polytechnic Ile-Oluji: A Discriminant Analysis Approach

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ABSTRACT

This study used Linear Discriminant Analysis (LDA) to develop a classification model for predicting blood pressure categories (low, normal, and high) among 240 students of Federal Polytechnic Ile-Oluji. The model utilized age, weight, and height data. Descriptive analysis showed 86.7% of participants had normal blood pressure, while 7.1% and 6.3% had low and high blood pressure, respectively. LDA identified age and weight as significant predictors, with the first discriminant function explaining 98.2% of the total variance. The model achieved an overall classification accuracy of 76.3%, with perfect prediction for low and high blood pressure categories. The findings highlight the importance of age and body weight as primary risk indicators and demonstrate LDA's effectiveness in health risk profiling. The results provide a basis for targeted interventions and preventive strategies within student populations, underscoring the potential for early identification and management of hypertension.

1. Introduction

1.1 Conceptual Background

Blood pressure is a vital indicator of cardiovascular health and plays a central role in the prevention and management of hypertension, a major contributor to cardiovascular morbidity and mortality worldwide (Whelton et al., 2017). Hypertension substantially increases the risk of stroke, coronary artery disease, heart failure, and renal complications. Globally, more than 1.28 billion adults aged 30–79 years are affected by elevated blood pressure, with the burden disproportionately concentrated in low- and middle-income countries (World Health Organization, 2021). In Nigeria, hypertension represents a serious public health challenge, affecting over 20 million individuals and approximately 38% of the adult population (Martins, 2019). Despite this high prevalence, awareness, early detection, and effective control remain inadequate, particularly among young adults.

Clinically, hypertension is defined as a systolic blood pressure of at least 130 mmHg and/or a diastolic blood pressure of at least 80 mmHg (Iqbal & Jamal, 2025). The American Heart Association provides a standardized classification of blood pressure into normal, elevated, stage 1 hypertension, stage 2 hypertension, and hypertensive crisis, which guides diagnosis, risk stratification, and treatment decisions (Whelton et al., 2017). These classifications emphasize the importance of early identification of blood pressure abnormalities, especially within younger populations where preventive interventions can yield long-term health benefits.

Blood pressure levels are influenced by a combination of demographic, physiological, and anthropometric factors. Among these, age, body weight, and height have been widely reported as key predictors of blood pressure variation across populations (Franklin et al., 2013; World Health Organization, 2021). Advancing age is associated with arterial stiffness and reduced vascular compliance, while excess body weight contributes to elevated blood pressure through increased cardiac workload and metabolic dysfunction. Height, though less frequently examined, has been suggested to influence blood pressure dynamics through vascular structural mechanisms (Islam et al., 2020; Cochran et al., 2021).

In tertiary institutions, students may be exposed to lifestyle patterns such as physical inactivity, poor dietary habits, stress, and irregular sleep, which can predispose them to abnormal blood pressure later in life. However, blood pressure abnormalities among students often remain undetected due to limited routine screening. Despite the growing burden of hypertension in Nigeria, empirical studies examining how age, weight, and height jointly influence blood pressure among students remain limited. Consequently, this study seeks to develop a classification model for blood pressure among students of the Federal Polytechnic Ile-Oluji using a discriminant analysis approach, with the aim of improving early risk identification and informing targeted health interventions.

1.2 Research Objectives

The main objective of this study is to develop a statistical classification model for predicting blood pressure categories among students of the Federal Polytechnic Ile-Oluji using Linear Discriminant Analysis (LDA). This objective is achieved through the following specific objectives, each of which corresponds directly to the analytical outputs presented in the results section:

i. To describe the demographic and anthropometric characteristics of the students in terms of age, weight, and height.
ii. To examine whether age, weight, and height significantly differ across blood pressure groups.

iii. To develop discriminant functions for classifying students into blood pressure categories.
iv. To assess the overall discriminative power and statistical significance of the classification model.
v. To evaluate the classification accuracy of the discriminant model.

1.3 Research Hypotheses

The following null hypotheses were formulated to guide the study and were tested at a 0.05 level of significance:

H_{01}: Age has no significant effect on blood pressure classification among students of the Federal Polytechnic Ile-Oluji.
H_{02}: Body weight does not significantly influence blood pressure classification among students of the Federal Polytechnic Ile-Oluji.
H_{03}: Height has no significant effect on blood pressure classification among students of the Federal Polytechnic Ile-Oluji.
H_{04}: Age, weight, and height do not jointly predict blood pressure classification among students of the Federal Polytechnic Ile-Oluji.

1.4 Significance of the Study

The findings of this study are expected to contribute meaningfully to public health research and practice in Nigeria. By identifying key anthropometric factors associated with blood pressure among students, the study provides evidence that can assist healthcare professionals in early detection and prevention of hypertension. The results may also support policymakers and educational institutions in designing targeted health awareness programs, routine screening initiatives, and preventive strategies aimed at young adults. Additionally, the study contributes to the existing literature by demonstrating the applicability of Linear Discriminant Analysis in health risk classification.

1.5 Scope of the Study

This study focuses on the development of a blood pressure classification model among students of the Federal Polytechnic Ile-Oluji. The investigation is limited to selected demographic and anthropometric variables, namely age, weight, and height, and their relationship with blood pressure categories (low, normal, and high). Other potential determinants of blood pressure, such as dietary habits, physical activity, genetic factors, and medication use, are outside the scope of this study. Data were obtained from a sample of students during the 2023/2024 academic session.

2. Literature Review

2.1 Concept of Blood Pressure and Hypertension

Blood pressure refers to the force exerted by circulating blood against the arterial walls and is commonly expressed as systolic and diastolic pressures. Persistently elevated blood pressure is clinically recognized as hypertension and is a major contributor to cardiovascular morbidity and mortality worldwide (Whelton et al., 2017). The World Health Organization (2021) estimates that more than 1.28 billion adults globally live with elevated blood pressure, emphasizing its significance as a global health concern. In Nigeria, hypertension prevalence remains high, affecting approximately 38% of the adult population (Martins, 2019), thereby necessitating early detection and risk stratification approaches.

2.2 Classification of Blood Pressure

The American Heart Association (2025) and Whelton et al. (2017) provide a standardized classification of blood pressure into normal, elevated, stage 1 hypertension, stage 2 hypertension, and hypertensive crisis. This classification framework is essential for categorizing individuals into risk groups and serves as the basis for statistical classification techniques, including discriminant analysis, which rely on clearly defined group memberships. In the present study, blood pressure is operationalized into low, normal, and high categories to facilitate predictive modeling and classification.

2.3 Empirical Evidence on Age and Blood Pressure

Age is one of the most consistently reported predictors of blood pressure variation. Studies have shown that blood pressure increases progressively with age due to arterial stiffening, reduced vascular elasticity, and age-related renal and hormonal changes (Franklin et al., 2013; van Varik et al., 2017). The National Heart, Lung, and Blood Institute (2024) reported that the likelihood of developing hypertension rises notably after the age of 40, while the American Heart Association (2017) observed that over 70% of individuals aged 60 years and above are hypertensive.

Empirical studies further support the role of age in blood pressure prediction. Odeigah et al. (2023) found a significant association between age and blood pressure using data analytic techniques, while Wolsk et al. (2017) demonstrated that age significantly influences hemodynamic responses even among healthy individuals. These findings justify the inclusion of age as a key predictor variable in discriminant-based blood pressure classification models, as adopted in the present study.

2.4 Empirical Evidence on Body Weight and Blood Pressure

Body weight has been widely documented as a major modifiable determinant of blood pressure. Excess body weight, particularly central obesity, contributes to elevated blood pressure through increased cardiac workload, insulin resistance, and neurohormonal dysregulation (World Health Organization, 2021). Landi et al. (2018) reported a strong positive association between body mass index and hypertension, while Odiana et al. (2024) found that increased body weight significantly impaired blood pressure control among hypertensive patients.

Weight reduction has also been shown to produce meaningful blood pressure improvements. The National Heart, Lung, and Blood Institute (2020) indicated that a 5–10% reduction in body weight yields substantial cardiovascular benefits, including blood pressure reduction. Hall et al. (2015) attributed these effects to improvements in vascular function and insulin sensitivity. Recent evidence by Yusni et al. (2024) further confirmed a positive correlation between body weight and blood pressure among young adults, supporting its relevance in student populations. These empirical findings align closely with the present study's results, where body weight emerged as a significant discriminator of blood pressure categories.

2.5 Empirical Evidence on Height and Blood Pressure

Height has received comparatively less attention in hypertension research, and existing findings remain mixed. Some studies suggest an inverse relationship between height and blood pressure, particularly pulse pressure, due to differences in arterial wave reflection and vascular geometry (Bourgeois, 2017; Islam et al., 2020). Cochran et al. (2021) also reported that taller adults tend to exhibit slightly lower blood pressure levels compared to shorter individuals.

However, other studies indicate that height may have limited predictive power when examined alongside stronger anthropometric variables such as age and weight. Cook et al. (1997) observed that while height contributed to blood pressure prediction in early life, its effect diminished when age and weight were controlled. This inconsistency in empirical evidence supports the findings of the present study, where height showed minimal contribution to blood pressure discrimination relative to age and weight.

2.6 Blood Pressure Classification and Predictive Modeling

Statistical classification techniques have increasingly been applied to health risk prediction. Linear Discriminant Analysis (LDA) has been shown to be effective in separating predefined health outcome groups using continuous predictor variables (Onuoha & Obimgba, 2021). Ogbogo (2019) emphasized that predictors with larger standardized discriminant coefficients contribute more meaningfully to group separation, while Balan (2023) noted that eigenvalues and canonical correlations provide useful measures of discriminant strength.

Empirical applications of discriminant analysis in health research demonstrate its robustness even when some statistical assumptions are violated, particularly with adequate sample sizes (Rencher, 2002; Tabachnick & Fidell, 2013). Chen and Zhang (2017) successfully applied LDA in disease classification contexts, reinforcing its suitability for blood pressure categorization. These methodological insights support the analytical approach adopted in the present study, which employs LDA to classify students into low, normal, and high blood pressure groups based on age, weight, and height.

2.7 Research Gap

Despite extensive evidence linking age and body weight to hypertension, limited studies have examined their combined discriminative power alongside height among student populations in Nigeria. Most existing research focuses on adult or clinical populations, leaving a gap in understanding blood pressure dynamics among young adults in tertiary institutions. Addressing this gap, the present study applies a discriminant analysis framework to classify blood pressure levels among students of the Federal Polytechnic Ile-Oluji, thereby contributing context-specific empirical evidence to hypertension risk profiling.

3. Methodology

3.1 Research Design

A quantitative approach was adopted for this research, involving systematic examination of measurable relationships and trends. Numerical data were gathered and analyzed to test hypotheses and derive conclusions, consistent with the study's focus on pinpointing risk factors associated with blood pressure variations.

3.2 Data Sources

Primary data was collected from students at Federal Polytechnic Ile-Oluji, including measurements of blood pressure, age, weight, and height from a sample of 240 students. Blood pressure readings were classified into three categories: low, normal, and high.

3.3 Population and Sample Size

The study population included all students enrolled at Federal Polytechnic Ile-Oluji during the 2023/2024 academic year. Using stratified random sampling, 20 students were randomly chosen from each of the 12 departments, resulting in a total sample size of 240 students.

3.4 Data Collection Methods

Information was collected through a mix of surveys and physical measurements. Age was recorded in years, weight in kilograms, height in inches, and blood pressure was measured and categorized based on systolic readings into low, normal, or high levels.

3.5 Data Analysis Techniques

Data coding and analysis were performed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics and discriminant analysis methods were applied to interpret the data.

3.6 Linear Discriminant Analysis

To fulfill the study objectives, Linear Discriminant Analysis (LDA) was utilized. This statistical method helps classify the dependent variable by using continuous independent variables (Onuoha & Obimgba, 2021). In this case, a discriminant function was developed to identify risk factors related to different blood pressure levels, classify students accordingly, and predict their risk of developing low, normal, or high blood pressure.

The discriminant function can be expressed as:

$$D_k = \beta_0 + \sum_{i=1}^{n} \beta_i X_i$$

Where:

D_k represents the discriminant score for group k.

β_0 is the intercept term.

B_i denotes the coefficient or weight assigned to the independent variable i.

X_i is the value of the independent variable i for the object k

The calculated discriminant function should be statistically significant. One way to assess this significance is through the eigenvalue associated with the function; a higher eigenvalue indicates better discrimination between groups (Balan, 2023). The impact of each predictor variable can be evaluated by examining its coefficient values, predictors with larger absolute standardized coefficients (1.00 or -1.00) contribute more significantly to the function's ability to discriminate (Ogbogo, 2019)

Assumptions of Discriminant Analysis

1. Homogeneity of variances across groups.
2. Predictors are independent of each other.
3. Samples are independent.

Although these assumptions are important, discriminant analysis can still yield valid results when applied to large sample sizes

3.7 Ethical Considerations

This study was conducted in accordance with established ethical standards for research involving human participants. Prior to data collection, informed consent was obtained from all participants after clearly explaining the purpose of the study, procedures involved, and their right to decline participation or withdraw at any stage without penalty. Participation was entirely voluntary. Confidentiality and anonymity of respondents were strictly maintained. Personal identifiers were excluded from the dataset, and all collected information was used solely for academic and research purposes. Data were securely stored and accessed only by the researchers to prevent unauthorized use. The study posed minimal risk to participants, as it involved non-invasive measurements. Ethical principles of respect, beneficence, and non-maleficence were upheld throughout the research process, and the study complied with institutional and national research ethics guidelines.

3.8 Descriptive Statistics

Descriptive statistical tools such as frequency counts, minimum and maximum values, means, and standard deviations were utilized to provide a summary of the dataset. These measures offered a general overview of the variables' characteristics and distributions.

4. Findings

Table 1a: Summary of Descriptive Statistics

Variables	Minimum	Maximum	Mean	Std. Dev.
Age	16	29	21.97	2.803
Weight (kg)	50	94	71.80	11.946
Height (Inches)	55.9	76.8	66.726	3.7911

As shown in Table 1, respondents' ages ranged from 16 to 29 years, reflecting a predominantly youthful sample consistent with a student population. The average age was approximately 22 years, with a standard deviation of 2.803, suggesting limited variation in age within the group. The participants' weights spanned from 50 kg to 94 kg, with a mean weight of about 71.80 kg. This implies that most respondents fall within a moderate weight range. The standard deviation of 11.946 indicates a notable level of variability in body weight among individuals. The height measurements varied between 55.9 inches and 76.8 inches, with an average of 66.73 inches, roughly equivalent to 5 feet 7 inches. A standard deviation of 3.79 inches indicates a moderate dispersion in height across the sample.

Table 2. Blood pressure distribution

Blood Pressure Group	Distribution
Low	17
Normal	208
High	15

Table 2 reveals that blood pressure classification among respondents revealed that 17 individuals (7.1%) were categorized as having low blood pressure. The majority, 208 students, representing 86.7% of the sample, fell within the normal blood pressure range. Meanwhile, 15 participants (6.3%) exhibited high blood pressure, reflecting a small portion of the sample.

These findings align with the observations by Odeigah et al. (2023) in their work "Association between blood pressure, body mass index, and age: A data analytic approach", as well as with the 2017 ACC/AHA blood pressure guidelines outlined by Whelton et al. (2017). Both references underscore the significant roles of age, body weight, and height in predicting blood pressure status and identifying individuals at risk for hypertension.

Table 3: Tests of Equality of Group Means

Variable	Wilks' Lambda	F	df1	df2	Sig.
Age	0.743	40.966	2	237	0.000
Weight	0.749	41.138	2	237	0.000
Height	0.979	2.483	2	237	0.086

Table 3 displays the outcomes of individual ANOVA tests conducted for each predictor (if only one dependent variable is used in MANOVA, Wilks' Lambda becomes equivalent to the F-test in ANOVA. So, Wilks' Lambda is like a multivariate generalization of the ANOVA F-test). The Wilks' Lambda for age (0.743) suggests it significantly contributes to differentiating between blood pressure groups. The F-value of 40.966 with a p-value less than 0.05 confirms that the mean age differs notably across the categories, supporting its relevance in group separation. This aligns with findings by Wolsk et al. (2016), which highlight the role of age in affecting hemodynamic responses during rest and exercise.

Similarly, the Wilks' Lambda for weight (0.749) and its corresponding F-value (41.138; $p < 0.05$) indicates that weight also plays a significant role in distinguishing between blood pressure levels. This supports the findings of Yusni et al. (2024), who reported a positive correlation between body weight and blood pressure among young adults. Conversely, height has a Wilks' Lambda of 0.979 and an F-value of 2.483, with a p-value of 0.086, suggesting that height does not significantly differentiate between the blood pressure categories in this sample.

Table 4. Box's M Test for Assumption of Homogeneity of Covariance Matrices

Box's M	F(Approx.)	Df1	Df2	Sig.
56.358	4.345	12	6361.822	0.000

Table 4 presents the results from Box's M test, which assesses whether the assumption of equal covariance matrices across groups holds. The significant p-value (0.000) indicates a violation of this assumption. However, previous studies (Rencher, 2002; Tabachnick & Fidell, 2013) note that discriminant analysis remains robust in the presence of such violations, especially with large sample sizes and absence of outliers (considering the minimum, maximum and mean of respective variables in Table 1), as is the case in this study.

Table 5. Summary of Discriminant Functions

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	0.860	98.2	98.2	0.680
2	0.015	1.8	100.0	0.123

Table 5 reports the eigenvalues and canonical correlations of the discriminant functions. The first function explains 98.2% of the total variance (eigenvalue = 0.860), demonstrating its strength as a predictor. The second function accounts for just 1.8% (eigenvalue = 0.015), indicating a relatively weak contribution. The canonical correlation for the first function (0.680) suggests a strong discriminating power, while the second function's correlation (0.123) implies minimal effectiveness in group separation.

Table 6. Wilks' Lambda for Discriminant Functions

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 and 2	0.529	150.076	6	0.000
2	0.985	3.611	2	0.164

Table 6 evaluates the overall effectiveness of the discriminant functions. A Wilks' Lambda of 0.529 for both functions combined, along with a significant chi-square value ($p < 0.05$), indicates that together, the functions significantly distinguish between the blood pressure categories. However, the second function alone (Wilks' Lambda = 0.985; $p > 0.05$) does not contribute meaningfully to discrimination.

Table 7. Standardized Canonical Discriminant Function Coefficients

Variable	Function 1	Function 2
Age	0.918	0.111
Weight	0.814	0.319
Height	0.079	0.962

Table 7 shows the standardized coefficients used in the discriminant functions. The first function is expressed as:

$D_1 = 0.918(Age) + 0.814(Weight) + 0.079(Height)$ …………………………….1

In this equation, age and weight are the strongest predictors, while height plays a lesser role.

The second function is represented as:

$D_2 = 0.111(Age) + 0.319(Weight) + 0.962(Height)$ …………………………….2

Here, height emerges as the most significant predictor, with weight and age contributing to a lesser extent.

Table 8. Classification Results

Actual Group	Predicted Group Membership	Total	% Correctly Classified
Low	17	0	100.0
Normal	33	151	72.6
High	0	0	100.0

Table 8 presents the classification outcomes of the model. All low and high blood pressure cases were correctly classified (100% accuracy), while 72.6% of normal cases were accurately identified. The overall model accuracy is 76.3%, suggesting a strong performance in predicting students' blood pressure levels based on age, weight, and height.

4.1 Discussion

The findings of this study contribute to the longstanding literature on blood pressure determinants by confirming, within a contemporary student population, patterns that have been widely documented in earlier epidemiological research. Consistent with classic studies by Cook et al. (1997) and Lakatta (2013), the results demonstrate that age and body weight are significant determinants of blood pressure variation, even among relatively young individuals. These earlier studies emphasized the progressive influence of aging and body mass on vascular resistance and arterial stiffness; the present study extends these insights by showing that such effects are already observable at the level of blood pressure classification among students.

The predominance of normal blood pressure observed in this study aligns with earlier population-based studies of young adults, which typically report lower prevalence rates of hypertension compared with older cohorts. However, the identification of both low and high blood pressure cases mirrors findings from earlier institutional and community studies, suggesting that cardiovascular heterogeneity exists even within youthful populations. Unlike older descriptive studies that primarily reported prevalence, this study advances the literature by demonstrating how anthropometric variables jointly differentiate clinically relevant blood pressure categories. The discriminant analysis results provide further confirmation of findings from earlier methodological studies that emphasize the importance of age and weight in cardiovascular risk modeling. The significant Wilks' Lambda values for age and weight are consistent with the observations of Bourke and Mills (2015), who highlighted the predictive strength of these variables in cardiovascular classification models. In contrast, the non-significant role of height observed in this study aligns with earlier research suggesting that stature has a weaker and more indirect association with blood pressure when body mass is accounted for.

From a methodological perspective, the dominance of the first discriminant function supports earlier theoretical work on multivariate classification, which posits that a small number of underlying dimensions often capture most of the group separation in biomedical data. While height emerged as the dominant contributor to the second function, its limited explanatory power confirms earlier findings that height-related effects are secondary in blood pressure differentiation. The high classification accuracy achieved for low and high blood pressure groups further distinguishes this study from older regression-based analyses, which often struggle to identify extreme cases with similar precision. Although the Box's M test indicated a violation of the homogeneity of covariance matrices assumption, the robustness of the classification outcomes is consistent with earlier methodological literature (Rencher, 2002; Tabachnick & Fidell, 2013), which argues that discriminant analysis remains reliable under such conditions when sample sizes are adequate. Overall, the findings reinforce classical theoretical insights while demonstrating the added value of classification-based approaches in contemporary student health research.

5. Conclusion and Recommendations

5.1 Conclusion

This study examined blood pressure patterns among students using a multivariate classification framework. The results show that the majority of students had normal blood pressure, while a smaller proportion exhibited low or high blood pressure, indicating early cardiovascular variation within a young population. Age and weight were identified as the most influential predictors of blood pressure status, whereas height played a limited role.

By applying Linear Discriminant Analysis, the study demonstrates that blood pressure categories can be effectively distinguished using simple anthropometric indicators. The strong classification performance for extreme blood pressure groups highlights the practical value of this approach for early risk identification. These findings reaffirm conclusions from earlier cardiovascular research while extending them through a categorical, rather than mean-based, analytical perspective.

5.2 Policy Implications

The results of this study have important implications for health policy and practice within tertiary institutions. In line with Sustainable Development Goal 3 (Good Health and Well-being), routine student health screening programs should prioritize regular blood pressure measurement alongside basic anthropometric assessments, particularly age and weight. Such measures can facilitate early detection of abnormal blood pressure and support preventive healthcare strategies.

Institutional health services can also adopt classification-based screening tools to identify students at higher cardiovascular risk and provide targeted interventions, including counseling and referral. Policies should emphasize weight management through campus-based physical activity programs and nutrition education, as body weight emerged as a key modifiable determinant of blood pressure. Integrating these strategies into student wellness initiatives can contribute to long-term reductions in cardiovascular disease risk and strengthen preventive health outcomes among young adults.

5.2 Recommendations

Based on the findings of this study, the following recommendations are proposed to enhance cardiovascular health management among students and support preventive healthcare objectives:

1. Institutional Health Screening: Tertiary institutions should implement routine blood pressure screening programs integrated with basic anthropometric assessments, particularly age and weight, to enable early detection of abnormal blood pressure among students.
2. Targeted Preventive Interventions: Campus health services should adopt data-driven classification tools to identify students at higher risk and provide targeted follow-up, counseling, and referrals rather than relying on uniform health campaigns.
3. Lifestyle and Weight Management Programs: Institutions should promote regular physical activity, healthy dietary practices, and weight management initiatives through structured wellness programs and accessible recreational facilities.
4. Health Education and Awareness: Cardiovascular health education should be incorporated into student orientation and ongoing wellness activities to encourage healthy lifestyle behaviors and long-term disease prevention.

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