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Research Article

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THE IMPACT OF BMI ON HEART RATE AND BLOOD PRESSURE: UNVEILING THE CARDIOVASCULAR CONNECTION

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Abstract

This research explores the connections between Body Mass Index (BMI) and cardiovascular health across different age and gender groups. A comprehensive analysis was conducted on 180 non-athlete participants, ranging from 18 to 70 years old. The findings indicate a significant correlation between BMI and heart rate, as well as blood pressure. The study aims to provide insights into these relationships by examining data from diverse age and gender cohorts. The results show that individuals with a healthy BMI (22.9 ± 2.7) tend to have favorable cardiovascular measures, highlighting the importance of BMI. In contrast, overweight (26.9 ± 2.66) and obese (32.3 ± 3.24) individuals exhibit distinct variations, with higher heart rates and blood pressures. Visual representations illustrate the trends across BMI categories. Statistical analysis reveals a moderate positive correlation between BMI and cardiovascular parameters, including heart rate (0.576), systolic blood pressure (0.563), and diastolic blood pressure (0.602). Multiple regression analysis indicates a strong fit (R = 0.663), with BMI explaining 44% of the variability in cardiovascular parameters. The model is statistically significant (F = 45.52) and does not exhibit significant autocorrelation (Durbin-Watson = 0.864), emphasizing BMI's significant role in predicting cardiovascular health.

Keywords: BMI, Heart Rate, Blood Pressure, Cardiovascular.

INTRODUCTION

The rising global prevalence of obesity has sparked significant concerns regarding its implications for public health. Body Mass Index (BMI), a widely accepted metric for categorizing individuals' weight status, has become a pivotal indicator of overall health. While the well-documented association between obesity and various health complications is acknowledged, the intricate relationship among BMI, heart rate, and blood pressure continues to be a subject of intense research and clinical interest.

Obesity stands out as the most prevalent form of malnutrition in developing countries, affecting both adults and children. Studies have consistently shown a correlation between obesity and elevated systolic blood pressure (SBP) and diastolic blood pressure (DBP). The weight in kg i.e. kilograms is in division by height in meters squared yields the BMI, which is the most frequently used indication for underweight or obesity in a population that is given. Epidemiological Studies has consistently demonstrated that blood pressure and body mass index (BMI) are positively correlated in Asian cultures. One important risk factor for both prehypertension and hypertension are obesity, highlighting the importance of early detection and intervention, including lifestyle modifications and weight management (Whelton et al., 2018). The relationship between obesity and cardiovascular disease is complex, with blood pressure and heart rate playing a crucial mediating role (Perçuku et al., 2019). Numerous studies have investigated the effects of BMI and obesity on HR and BP response while doing and after exercise, demonstrating the significant influence of BMI on the heart's response to physical exertion. This retrospective analysis aims to examine the changes in BP and heart rate associated with changes in BMI, building on existing research that has shown a strong correlation between BMI and cardiovascular risk factors (ZEIGLER et al., 2018)

OVERVIEW OF Cardiovascular Parameters

Heart rate and BMI: Cardiovascular health is closely tied to BMI, HR, and BP. Research has shown that higher BMI values are linked to increased resting heart rates, indicating added strain on the cardiovascular system (Wajahat Ali, n.d.)Moreover, obesity's impact on heart rate variability (HRV) and BP has been extensively studied. HRV is a valuable non-invasive tool for assessing autonomic nervous system activity and cardiovascular disease risk. While the relationship

between HRV and BMI has been explored, findings in obese individuals have been inconsistent (Hassya et al., 2022)

Blood pressure and BMI: The connection between BMI and blood pressure is complex, with obesity being a significant risk factor for hypertension (Zhang & Wang, 2020). However, BMI does not accurately reflect body fat distribution, introducing some ambiguity. Epidemiological studies consistently show a correlation between higher BMI levels and increased blood pressure. Hypertension linked to obesity is a well-established risk factor for cardiovascular diseases. Mechanistically, heightened sympathetic nervous system activity, altered vascular function, and insulin resistance contribute to elevated blood pressure levels (Thu Tran et al., 2018)

Heart rate and blood pressure: A high resting heart rate (RHR) is recognized as a significant factor associated with increased mortality risk.[9] High RHR is linked to myocardial infarction and may serve as an early marker of cardiovascular disease in childhood, influenced by obesity and other cardiovascular risk factors (Dua et al., 2014) Heart rate is a crucial element in hypertensive patient assessment, and addressing elevated heart rate through lifestyle changes or interventions can play a significant role in managing hypertension and reducing cardiovascular risks (Cooney et al., 2010). This essay aims to elucidate the physiological mechanisms underlying the relationships between BMI, blood pressure, and heart rate, providing valuable insights for individuals and medical practitioners alike (Wang et al., 2014). The complex link between BP, HR, and BMI is examined in this essay (Christofaro et al., 2017). Our objective is to elucidate the physiological mechanisms that underpin the ways in which BMI affects blood pressure and heart rate by a synthesis of the literature and the presentation of new findings. These relationships are important for both the individuals seeking to improve their general well-being, health and cardiovascular health as well as for medical practitioners (Reule & Drawz, 2012).

RESEARCH METHODOLOGY AND RESULTS

i. **Subjects**: This study recruited 180 participants, ranging from 18 to 70 years old. To ensure diverse representation, we divided them into three age categories: young adults (17-30 yr, n=60), adults aged between (31-50 yr, n=60), and adults which are (51-70 yr, n=60). Each age group had an equal number of male and female participants. All participants were non-athletes who provided informed consent. We strictly adhered to ethical guidelines to ensure their privacy and safety.

ii. **BMI Measurement:** To assess body composition, we calculated each participant's Body Mass Index (BMI). We observed height and weight using standard methods i.e height to the closest 0.1 cm and weight to the closest 0.1 kg using a stadiometer. We categorized the resulting BMI values as per World Health Organization (WHO) classifications following are the three categories underweight (BMI < 18.5), normal weight (BMI 18.5-24.9), overweight (BMI 25.0-29.9), and obese (BMI ≥ 30.0). Participants were assigned to these BMI categories based on their calculated values.

iii. **Experimental Design*:*** Our main goal in this experimental work was to investigate the association between cardiovascular health measures, namely HR and BP, and age as well as Body Mass Index (BMI). Three age categories were used to group study participants: 17–30 years old, 31–50 years old, and 51 years and older. A thorough framework for analysis was created by further classifying participants according to their BMI, as illustrated in Figure 1.

iv.

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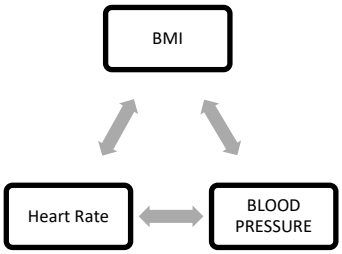
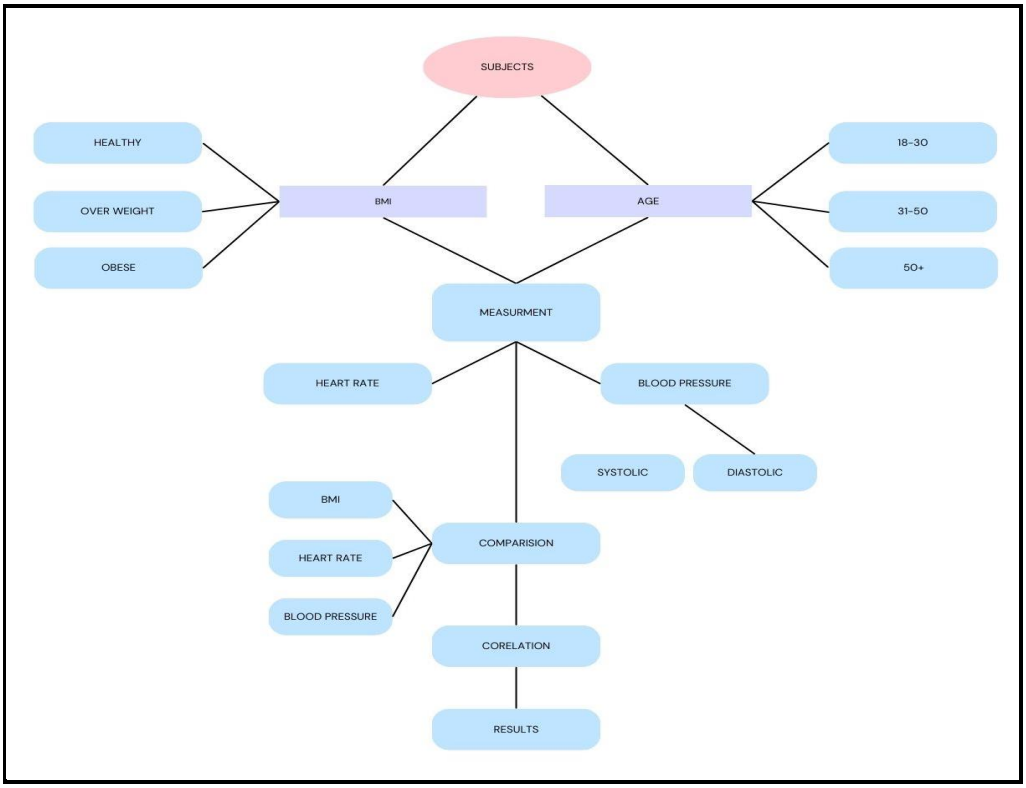


Figure 1 Experimental Design



Non-invasive techniques were used to capture each participant's blood pressure and heart rate as part of the data gathering process. Standard protocols were followed to take blood pressure readings and to monitor heart rates while the subjects were at rest. As seen in Figure 2, the gathered data were then arranged in accordance with the predefined age and BMI groups.

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The data analysis was conducted using Statistical Package for the Social Sciences (SPSS) software. To investigate any correlations between cardiovascular parameters, age, and BMI, we performed correlation analysis. Also to find the correlation between age group and BMI and different gender and BMI.

Figure 2 Data collection

Recording Device: To measure critical physiological parameters including BP, HR, and BMI, health monitoring equipment is necessary. All the devices used were CE marked and FDA Approved such as Omron M2 blood pressure monitor, Fitbit fitness trackers to record Heart Rate. Then BMI was calculated using reliable sources such as WHO.

Results

The subjects were split in three groups which are healthy, obese, and overweight. The observed mean BMI, accompanied by a standard deviation, is 23.3 ± 2.3, while the HR and systolic-diastolic blood pressure are recorded as 86.7 ± 3.82, 125.0 ± 5.61, and 83.1 ± 4.22, respectively (as illustrated in Figure 3).

Table 2 provides insights into overweight males, featuring a mean age of 36.34 with a SD of 2.8. The mean BMI, with a standard deviation, is 27.5 ± 2.61, along with a heart rate of 95.23 ± 4.15 and systolic-diastolic blood pressure recorded as 132.4 ± 5.61 and 90.23 ± 4.21, respectively (as depicted in Figure 4). Table 3 outlines data for obese males, showcasing a mean age of 32.21 with a standard deviation of 1.9. The mean BMI, accompanied by a standard deviation, is 32.56 ± 3.41. Additionally, the heart rate and systolic-diastolic blood pressure are reported as 124.2 ± 4.98, 139.4 ± 5.61, and 104.2 ± 5.49, respectively (as illustrated in Figure 5). The data in Table 4 pertains to healthy females, revealing a mean age of 33.17 with a standard deviation of 2.4. The mean BMI, accompanied by a standard deviation, is 22.54 ± 3.10. The recorded heart rate and systolic-diastolic blood pressure are 84.13 ± 3.78, 122.51 ± 5.24, and 81.52 ± 3.98, respectively (as depicted in Figure 6). Table 5 offers insights into overweight females, featuring a mean age of 34.11 with a standard deviation of 2.5. The mean BMI, accompanied by a standard deviation, is 26.36 ± 2.71, along with a heart rate of 93.8 ± 4.19 and systolic-diastolic blood pressure recorded as 131.4 ± 4.68 and 89.21 ± 4.28, respectively (as illustrated in Figure 7). Table 6 presents data for obese females, showcasing a mean age of 31.14 with a standard deviation of 2.1. The mean BMI, accompanied by a standard deviation, is 32.19 ± 3.08. The heart rate and systolic-diastolic blood pressure are reported as 122.6 ± 4.74 and 138.33 ± 5.53, respectively (as depicted in Figure 8).

TABLE 1
Healthy Male Data.

Healthy Male	18-30	30-50	50+	Total
BMI ±SD (Kg/m2)	22.2± 2.07	24.7± 2.57	23.1± 2.26	23.3± 2.3
Heart Rate ±SD	78.3± 3.46	93.7± 4.13	88.3± 3.87	86.7± 3.82
BP systolic (mmHg)	123.4± 5.52	124.4± 7.71	127.3± 3.6	125.0± 5.61
BP distolic (mmHg)	81.9± 4.35	83.6± 4.38	86± 3.94	83.1± 4.22

TABLE 2
Overweight Male Data.

Overweight Male	18-30	30-50	50+	Total
BMI ±SD (Kg/m2)	26.3± 2.07	28.7± 3.57	27.6± 2.2	27.5± 2.61
Heart Rate ±SD	89.7± 4.36	102.3± 5.2	93.7± 2.9	95.23± 4.15
BP systolic (mmHg)	129.2± 5.52	132.1± 7.71	135.9± 3.6	132.4± 5.61
BP diastolic (mmHg)	87.9± 4.24	89.6± 3.48	93.2± 4.93	90.23± 4.21

TABLE 3
Obese Male Data.

Obese Male	18-30	30-50	50+	Total
BMI ±SD (Kg/m2)	31.2± 4.72	34.4± 2.42	32.1± 3.1	32.56± 3.41
Heart Rate ±SD	99.2± 4.96	130.7± 6.2	142.9± 3.8	124.2± 4.98
BP systolic (mmHg)	137.7± 5.521	141.5± 7.71	139.2± 3.6	139.4± 5.61
BP diastolic (mmHg)	99.3± 5.41	107.5± 6.83	105.9± 4.23	104.2± 5.49

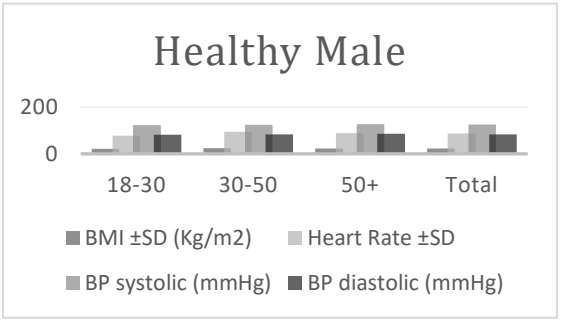

Figure 4 Healthy Male

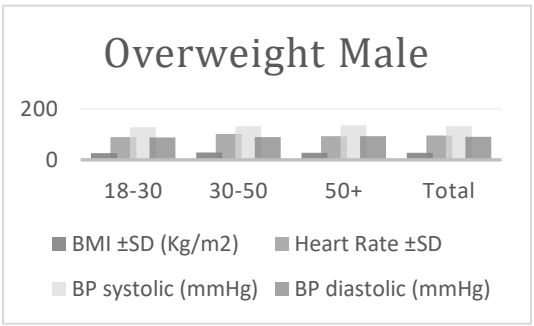

Figure 5 Overweight Male

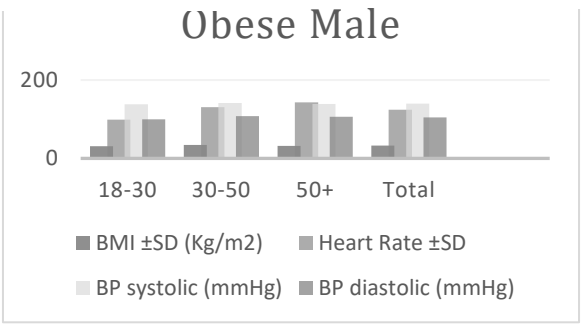

Figure 6 Obese Male

TABLE 3 Healthy Female Data.

Healthy Female	**18-30**	**30-50**	**50+**	**Total**
BMI ±SD (Kg/m2)	21.23± 3.27	24.10± 2.13	22.31± 3.91	22.54± 3.10
Heart Rate ±SD	76.7± 3.46	91.2± 4.1	84.5± 3.8	84.13± 3.78
BP systolic (mmHg)	121.2± 5.21	120.15± 6.17	126.2± 4.34	122.51± 5.24
BP diastolic (mmHg)	79.9± 4.57	81.42± 3.23	83.46± 4.14	81.52± 3.98

TABLE 4 Overweight Female Data.

Overweight Female	**18-30**	**30-50**	**50+**	**Total**
BMI ±SD (Kg/m2)	25.27± 2.07	27.12± 2.65	26.69± 3.42	26.36± 2.71
Heart Rate ±SD	87.3± 4.39	101.5± 4.5	92.6± 3.7	93.8± 4.19
BP systolic (mmHg)	127.3± 5.16	130.45± 6.4	136.7± 2.5	131.4± 4.68
BP diastolic (mmHg)	86.3± 4.65	88.75± 3.88	92.60± 4.33	89.21± 4.28

TABLE 5 Obese Female Data.

Obese Female	**18-30**	**30-50**	**50+**	**Total**
BMI ±SD (Kg/m2)	30.41± 4.32	32.41± 2.12	33.75± 2.8	32.19± 3.08
Heart Rate ±SD	98.1± 4.36	129.3± 6.54	140.4± 3.32	122.6± 4.74
BP systolic (mmHg)	136.66± 5.76	140.4 ± 7.65	138.1± 3.2	138.33± 5.53
BP distolic (mmHg)	98.21± 5.54	106.36± 6.34	105.26± 3.98	138.33± 5.28

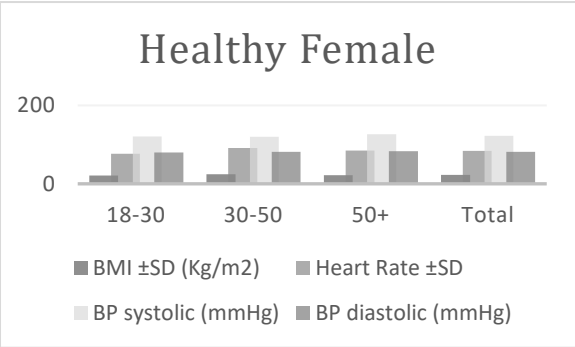

Figure7 Healthy Female

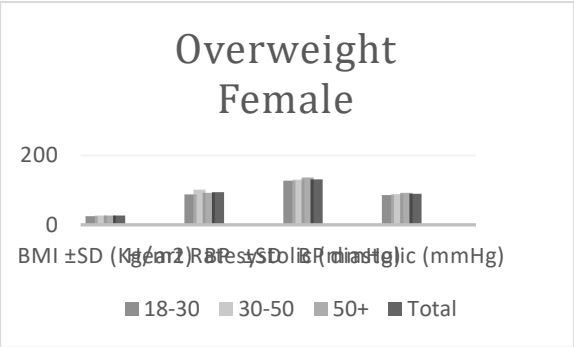

Figure 8 Overweight Female

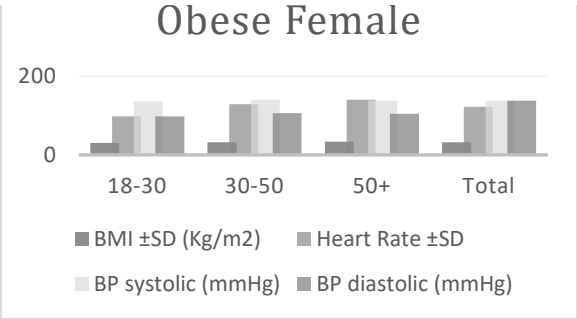

Figure 9 Obese Female

Discussion

To be more precise, the mean BMI for people who are in the healthy range is 22.9 ± 2.7. Moreover, a detailed analysis of the cardiovascular parameters in this subgroup shows that the mean diastolic blood pressure is 82.3 ± 4.1 mmHg, the mean systolic blood pressure is 123.7 ± 5.42 mmHg, and the average resting heart rate is 85.4 ± 3.8 beats per minute. These combined results highlight the importance of keeping a healthy BMI as a possible factor in good cardiovascular health, as demonstrated by the observed mean values in this specific sample of individuals, which includes both male and female participants, as displayed in Table 7 and Figure 9. When examining BMI categories, the average values for overweight people (BMI 26.9 ± 2.66) indicate different cardiovascular characteristics. It is noteworthy that, in this subgroup, Table 8 and Figure 10 reveal that the mean diastolic blood pressure is 123.7 ± 5.42 mmHg, the mean systolic blood pressure is 131.9 ± 5.14 mmHg, and the average resting heart rate is 94.5 ± 2.17 beats per minute in Table 8 and Figure 10. Moving into the obese BMI category (BMI 32.3 ± 3.24), the cardiovascular profile demonstrates further variations, with an elevated average resting heart rate of 123.4 ± 4.86 BPM, a mean systolic blood pressure of 138.8 ± 5.57 mmHg, and a mean diastolic BP of 103.7 ± 5.38 mmHg shown in Table 9 and Figure 11. To visually represent these trends, the corresponding mean values for the healthy, overweight, and obese BMI categories can be effectively illustrated in Figure 9-11. Each line graph would portray the progression of mean values for resting heart rate, systolic blood pressure, and diastolic blood pressure across the three BMI categories, providing a comprehensive visual overview of the cardiovascular variations associated with different BMI classifications.

Table 7: Healthy subjects Data.

Healthy	**male**	**Female**	**Total**
BMI ±SD (Kg/m2)	23.3± 2.3	22.5± 3.10	22.9±2.7
Heart Rate ±SD	86.7± 3.82	84.1± 3.78	85.4±3.8
BP systolic (mmHg)	125.0± 5.61	122.51± 5.24	123.7±5.42

Table 8: Overweight subjects Data.

Over weight	male	Female	Total
BMI ±SD (Kg/m2)	27.5± 2.61	26.3± 2.71	26.9± 2.66
Heart Rate ±SD	95.23± 4.15	93.8± 4.19	94.5± 2.17
BP systolic (mmHg)	132.4± 5.61	131.4± 4.68	131.9±5.14

Table 9: Obese subjects Data.

Obese	male	Female	Total
Heart Rate ±SD	124.2 ± 4.98	122.6± 4.74	123.4±4.86
BP systolic (mmHg)	139.4 ± 5.61	138.3± 5.53	138.8±5.57
BP distolic (mmHg)	104.2± 5.49	103.2± 5.28	103.7±5.38
BMI ±SD (Kg/m2)	32.5 ± 3.41	32.1± 3.08	32.3±3.24

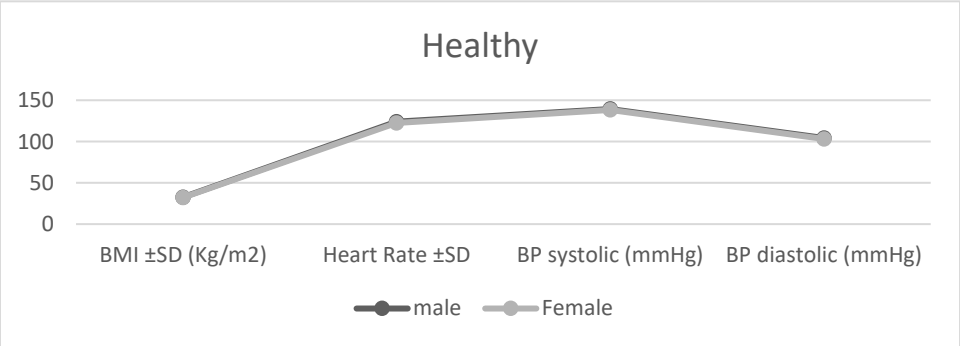

Figure 9 Healthy comparison

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.663[a]	.440	.430	3.3017899863	.440	45.522	3

Model Summary[b]

Model	Change Statistics		Selection Criteria			
	df2	Sig. F Change	Akaike Information Criterion	Amemiya Prediction Criterion	Mallows' Prediction Criterion	Schwarz Bayesian Criterion

Figure 11 Obese Comparison

Model Summary[b]

Model	Durbin-Watson
1	.864

a. Predictors: (Constant), Distolic±SD(mmhg), Heart rate±SD, Systolic±SD(mmhg)

b. Dependent Variable: BMI±SD

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.

Figure 10 Over Weight Comparison

	Total	3385.729	177			

a. Dependent Variable: BMI±SD

b. Predictors: (Constant), Distolic±SD(mmhg), Heart rate±SD, Systolic±SD(mmhg)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.141	2.911		.049	.961
	Heart rate±SD	.082	.019	.332	4.326	<.001
	Systolic±SD(mmhg)	.102	.038	.260	2.705	.008
	Distolic±SD(mmhg)	.076	.050	.170	1.517	.131

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
BMI±SD	27.902178334	4.3736038987	178
Heart rate±SD	94.93	17.635	178
Systolic±SD(mmhg)	130.56	11.194	178
Distolic±SD(mmhg)	87.5692	9.75240	178

Correlations

		BMI±SD	Heart rate±SD	Systolic±SD (mmhg)	Distolic±SD (mmhg)
Pearson Correlation	BMI±SD	1.000	.576	.563	.602
	Heart rate±SD	.576	1.000	.500	.669
	Systolic±SD(mmhg)	.563	.500	1.000	.806
	Distolic±SD(mmhg)	.602	.669	.806	1.000
Sig. (1-tailed)	BMI±SD	.	<.001	<.001	<.001
	Heart rate±SD	.000	.	.000	.000
	Systolic±SD(mmhg)	.000	.000	.	.000
	Distolic±SD(mmhg)	.000	.000	.000	.
N	BMI±SD	178	178	178	178
	Heart rate±SD	178	178	178	178
	Systolic±SD(mmhg)	178	178	178	178
	Distolic±SD(mmhg)	178	178	178	178

Coefficients[a]

Model		95.0% Confidence Interval for B		Correlations		
		Lower Bound	Upper Bound	Zero-order	Partial	Part
1	(Constant)	-5.604	5.886			
	Heart rate±SD	.045	.120	.576	.312	.245
	Systolic±SD(mmhg)	.027	.176	.563	.201	.154
	Distolic±SD(mmhg)	-.023	.175	.602	.114	.086

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Heart rate±SD	.548	1.825
	Systolic±SD(mmhg)	.348	2.874
	Distolic±SD(mmhg)	.256	3.903

Figure 12 SPSS analysis

Correlation between BMI, Heart rate and Blood Pressure: Within the cohort of 178 participants, an examination of descriptive statistics unveils a mean Body Mass Index (BMI) of 27.90, accompanied by a standard deviation of 4.37. Furthermore, the mean values for cardiovascular parameters are discerned, with the mean heart rate registering at 94.93, the mean systolic blood pressure at 130.56, and the mean diastolic blood pressure at 87.56.

To explore the associations between BMI and cardiovascular parameters, Pearson correlation coefficients were employed. The outcomes depict moderate positive correlations, specifically 0.576 for heart rate, 0.563 for systolic blood pressure, and 0.602 for diastolic blood pressure.

Transitioning to the multiple regression analysis, the model summary portrays a robust fit denoted by an R-value of 0.663. The R-square value, indicative of the proportion of variance explicated, stands at 0.440, signifying that 44% of the variability in the dependent variable is elucidated by the independent variables. The adjusted R-square, a metric accounting for predictors and sample size, is noted at 0.430 as shown in Figure 12.

Furthermore, the overall model's statistical significance is substantiated by an F-change statistic of 45.52, where the degrees of freedom for the model (df1) amount to 3, and for the residuals (df2), they total 174. The Durbin-Watson statistic, scrutinizing the independence of residuals, yields a value of 0.864, indicative of the absence of significant autocorrelation.

In synthesis, the regression analysis posits BMI as a consequential predictor of cardiovascular parameters, underscored by the positive correlation coefficients and the overarching statistical significance of the model.

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