A study on relationship between Body Mass Index and Cardiorespiratory Endurance among rural male college students of Haryana state

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ABSTRACT

Low cardio respiratory fitness in young adults has emerged as an important factor for developing cardiovascular comorbidies. Increased body fat as predicted by body mass index is an additional factor for developing cardiovascular diseases. The current study was designed to find out possible association between BMI and cardio respiratory fitness among young male college students. The study population included 500 rural male college students from different colleges of Haryana state. Undergraduate, graduate, and postgraduate students who were in the adolescent age group of 18–25 years were included in the study. For assessment of Cardio respiratory endurance 9 min run/ walk test from AAHPERD health related physical fitness battery was used. For assessing BMI status of the students BMI criteria for Asia population proposed by WHO was used. There was a prevalence of overweight (29.8%), obesity I (11.6%) and obese II (0.2%) students. Most obese I students were found in the age group 17-19 years. Independent T test was used to compare the means between obese and non- obese students For descriptive analysis, mean and standard deviation values were employed. Pearson's product-moment correlation coefficient (r) with 95% confidence ($P < 0.05$) was applied to determine relationship between dependent and independent variable. There was a mildly significant negative correlation (r -0.182, $P < 0.01$) between BMI and Cardio respiratory endurance. The value of ANOVA is found to be 4.577 which is significant at 5% level of significance, this shows that there is a significant difference in cardio respiratory endurance of students according to BMI. There was a significant difference in cardio respiratory endurance in the mean cardio respiratory endurance when compared between obese and not obese students.

Keywords

BMI, Obesity, Cardio respiratory fitness, AAHPERD

Introduction

In the realm of human health and fitness, two critical components often take center stage: Body Mass Index (BMI) and cardiorespiratory endurance. These two facets of human physiology have garnered significant attention from researchers, healthcare professionals, and fitness enthusiasts alike due to their profound implications for overall well-being. As we embark on a journey to explore the intricate relationship between BMI and cardiorespiratory endurance, it becomes apparent that their interplay is multifaceted, dynamic, and influenced by a myriad of factors. Body Mass Index, commonly abbreviated as BMI, serves as a fundamental metric for assessing an individual's body composition. Cardiorespiratory endurance, on the other hand, refers to the ability of the cardiovascular and respiratory systems to sustain prolonged physical activity. It is a key component of physical fitness and is often assessed through measures such as maximal oxygen consumption (VO2 max), which reflects the body's capacity to utilize oxygen during exercise. Improving cardiorespiratory endurance not only enhances athletic performance but also plays a crucial role in reducing the risk of cardiovascular diseases, improving metabolic health, and enhancing overall quality of life.

However, it is essential to recognize that the relationship between BMI and cardiorespiratory endurance is not solely determined by adiposity. Genetic predisposition, muscle mass, body composition, age, sex, and ethnicity are among the myriad of factors that can modulate this relationship. For instance, individuals with a higher proportion of lean muscle mass may exhibit better cardiorespiratory fitness despite having a higher BMI, as muscle tissue is metabolically active and contributes to overall metabolic rate and energy expenditure.

Moreover, recent research has challenged the notion that all forms of obesity are inherently detrimental to cardiorespiratory health. The concept of "metabolically healthy obesity" has gained traction, referring to individuals with obesity who exhibit favorable metabolic profiles, including normal insulin sensitivity, lipid levels, and blood pressure, despite being overweight or obese. These individuals may possess unique genetic or physiological adaptations that confer protection against metabolic dysfunction and cardiovascular disease, thereby preserving cardiorespiratory fitness to some extent.

Conversely, individuals with a normal BMI may still be at risk for cardiovascular disease if they exhibit poor cardiorespiratory fitness due to factors such as physical inactivity, smoking, or underlying medical conditions. Thus, while BMI serves as a useful screening tool for assessing population-level trends in weight status, it should be interpreted in conjunction with other measures of health and fitness, including cardiorespiratory endurance.

Obesity as major lifestyle concern

The health and well-being of college students are crucial, given that they undergo a pivotal transition from adolescence to adulthood. An increasingly prevalent health issue during this period is obesity, characterized by an accumulation of excess body fat, which can significantly impact overall health. Obesity is linked to various health complications such as cardiovascular diseases, diabetes, and certain types of cancer, posing a substantial global public health concern. In the United States, obesity rates have been steadily climbing, with recent estimates indicating that more than one-third of adults and nearly one-fifth of children and adolescents are affected by this condition (Hales et al., 2020)..

Obesity stands as the most widespread chronic ailment globally, with projections indicating that over 1 billion individuals will grapple with it by 2030. The escalated rates of obesity-linked mortality and accompanying conditions like diabetes, cardiovascular diseases, chronic kidney diseases, and various cancers are equally alarming, resulting in an average of 5 million deaths and 160 million disability-adjusted life-years (World Obesity Atlas, 2022). Consequently, shifts towards decreased productivity and heightened healthcare service utilization are anticipated to impose a significant economic burden (Schneider et al., 2020; Czernichow et al., 2021). There exists a pressing need to treat obesity as a chronic, progressive, and recurring illness to enhance outcomes for those affected. Suboptimal lifestyle choices serve as a primary preventable factor contributing to obesity and its associated conditions (Safaei et al., 2021). Therefore, interventions aimed at improving lifestyle present an opportunity to enhance obesity management.

Numerous healthy lifestyle factors, including regular physical activity, abstaining from smoking, and adhering to nutritious dietary patterns, whether observed individually or collectively, have been associated with reduced disease incidence and mortality rates in the general populace (Zaninotto, Head & Steptoe, 2020). Despite existing nutritional guidelines, there's limited understanding regarding these relationships across the spectrum of body mass index (BMI), particularly among adults with obesity. The scarce research available indicates that specific healthy lifestyle behaviors, such as avoiding smoking, following healthy dietary patterns like the Mediterranean diet, or engaging in more leisure-time physical activity, may mitigate the risks of chronic diseases and mortality associated with obesity (Roos et al., 2017).

Behavioral factors are often interconnected, and individuals tend to adopt interrelated lifestyle patterns (Fuglestad et al., 2012). Hence, it's crucial to analyze lifestyle factors collectively to comprehensively assess their impact on health. Studies have demonstrated that meeting multiple healthy lifestyle criteria reduces the risks of cardiovascular disease, cardiovascular mortality, and all-cause mortality among adults with overweight and obesity (Khaw et al., 2008).

However, the extent to which specific combinations of healthy lifestyle factors correlate with reduced risks of obesity-related diseases beyond cardiovascular disease remains uncertain. Moreover, whether a healthy lifestyle can mitigate the risk of obesity itself requires further elucidation. This study aims to assess the relationship between a key health-related physical fitness component, such as Cardiorespiratory fitness, and the occurrence of major obesity-related diseases in adults with obesity compared to those with normal weight. While the prevalence of obesity among adolescents has plateaued at a high level in developed nations, it continues to rise in developing countries. In addition to the numerous short-term effects of obesity, such as cardio-metabolic, respiratory, musculoskeletal, endocrine, and psychosocial issues, along with an increased risk of cancer, a substantial percentage of children and adolescents with obesity persist in their condition into adulthood, leading to the development of several chronic diseases and, in some cases, premature death.

Risks of Obesity

Obesity can exert a multitude of adverse effects on the body, impacting various systems from head to toe. Among the prevalent health issues associated with obesity are high blood pressure, elevated cholesterol levels, diabetes, metabolic syndrome, infertility and PCOS in women, and an increased risk of certain cancers. Notably, obesity heightens the susceptibility to various types of cancer, such as breast, colon, and endometrial cancers, and may complicate their detection and treatment. Additionally, obesity significantly influences an individual's quality of life, often leading to joint pain, particularly in the hips, knees, and ankles, which can hinder physical activity and exacerbate weight concerns. Moreover, obesity can contribute to diminished self-esteem and confidence, impacting mental well-being. Young individuals diagnosed with diabetes early in life should prioritize prompt intervention and management. Obesity constitutes a major risk factor for type 2 diabetes, and young individuals with excess weight may face heightened risks of complications, underscoring the importance of weight loss and overall health improvement endeavors.

How to Manage Obesity?

Effectively addressing obesity requires a comprehensive approach, incorporating various strategies such as lifestyle modifications, pharmacological interventions, and surgical procedures. Central to obesity management is the adoption of a balanced diet and regular physical activity. A nutritious diet should entail appropriate proportions of carbohydrates, proteins, and fats, while minimizing the intake of sugar, saturated fats, and processed foods. Notably, certain dietary patterns, such as traditional Indian diets, which often feature high carbohydrate content, may contribute to weight gain. Thus, reducing carbohydrate intake while increasing protein consumption, incorporating foods like fish, poultry, and lean meats, is pivotal for weight loss. Furthermore, limiting the consumption of calorie-dense foods aids in reducing overall calorie intake. Engaging in regular physical activity is vital for calorie expenditure and overall health enhancement, with recommended guidelines suggesting at least 150 minutes of moderate aerobic exercise or 75 minutes of vigorous aerobic exercise weekly, with even a 30-minute brisk walk proving beneficial. These principles are pertinent for addressing childhood obesity as well.

Interaction of Obesity and CRF

The relationship between obesity and cardiorespiratory fitness has been well-documented in the literature, with numerous studies reporting an inverse relationship between the two variables. Research has consistently shown that individuals who are overweight or obese tend to have lower levels of cardiorespiratory fitness compared to normal weight counterparts. This relationship is thought to be driven by a number of factors, including the increased metabolic demands placed on cardiovascular and respiratory systems by excess bodyweight, as well as the negative impact of obesity on physical levels and exercise capacity.

Among college students, obesity is a particularly pressing issue, with studies regarding high rates of prevalence among this population. A study conducted by jayawardena et al. (2012) found that obesity rates among college students in the united states were as high as 40%, highlighting the need for targeted inteventions to address this growing health concern. One of the key factors contributing to obesity is low levels of cardiorespiratory fitness, which refers to the ability of the cardiovascular and respiratory systems to supply oxygen to muscles during prolonged physical activity. Cardiorespiratory fitness is an important component of overall fitness and is closely related to health outcomes, with higher levels of fitness associated with reduced risk of chronic diseases and improved overall well-being.

Low cardiorespiratory fitness in children and adolescents has been associated with increased body fatness, hypertension, increased risk of metabolic syndrome and worse academic performance. Previous studies have shown a strong correlation between increased body mass index (BMI) and reduced cardiorespiratory fitness in children and adolescents. The association between increased body weight and decreased cardiorespiratory fitness is unequivocal in most of the studies but its interaction with muscle performance is more ambiguous. Furthermore, most of the studies examining the association between childhood and adolescence physical fitness and BMI are cross-sectional (Petrovics et al., 2021).

While the relationship between obesity and cardiorespiratory fitness has been well established in adult population, there is limited research on this relationship among college students, particularly in males. Understanding the relationship between obesity and cardiorespiratory in this population is important for several reasons. First, college students represent a unique demographic group with distinct health behavior and risk factors that may influence the relationship between obesity and fitness. Second, college is a critical period of transition in which individuals establish long-term health habbits that can have lasting implications for their health and well-being. In our study, we have measured the cardiorespiratory fitness of adolescents between 17 and 25 years of age and investigated the possible association between overweight and obesity and cardiorespiratory fitness in rural male college students.

Criteria for determining BMI

The obesity level of the participants was determined using body mass index (BMI) sex- and age-specific cutoff points by calculating their BMI, using the formula BMI = weight / (height) metres. The cut offs for body mass index (BMI) proposed by the WHO expert committee for Asian people are listed in the table below. (World Health Organization. Regional Office for the Western Pacific, 2013)

Table 1-BMI Classification

Underweight	<18.5
Normal weight	18.5–22.9
Overweight	23–24.9
Obese	≥25

Table 1 depicts BMI classification of students, underweight students are categorized at <18.5, normal weight students are categorized between 18.5–22.9
,overweight students are catrgorized between23–24.9 and obese students are categorized at ≥25.

Results and Analysis

Table 2: Profile of college students

	N	Minimum	Maximum	Mean	Std. Deviation
AGE	500	17	25	20.25	1.660
BMI	500	18.17	30.11	23.1590	2.33015
WEIGHT_kg	500	45.5	86.0	63.032	7.1501
HEIGHT_cm	500	150.0	185.5	164.982	5.9515
Valid N (listwise)	500				

Table 2, depict profile of students in the study. The researcher have taken data of 500 respondents and used a scale EAT-26 which results that for dieting the minimum score is found to be 0 and maximum score is found to be 27 with mean 10.85 and standard deviation 5.492, for bulimia food preoccupation the minimum score is found to be 0 and maximum score is 16 with mean 5.05 and standard deviation 3.156, for oral control the minimum score is found to be 0 and maximum score is found to be 15 with mean 5.48 and standard deviation 2.910 and for eating attitude the minimum score is found to be 0 and maximum score is found to be 43 with mean 19.41 and standard deviation 8.8022. From the table it can be interpreted that there is a maximum score for dieting and minimum score for oral control and the mean is highest in case of dieting. So the researcher is of the opinion that are of a habit of dieting in comparison to oral control and less are related to bulimia food preoccupation.

Table 3- Frequency distribution among diffrerent Age groups of students

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	17-19	176	35.2	35.2	35.2
	20-22	273	54.6	54.6	89.8
	23-25	51	10.2	10.2	100.0
	Total	500	100.0	100.0	

Table 3, depict frequency of students according to age group. During the study 500 male students in the age group of 17 to 25 years were enrolled where 35.2% students fall in (17-19 years), 54.6% students in (20-22 years) and only 10.2% students fall in (23-25 years) age category.

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Table 4- BMI level of students

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Underweight(<18.5)	12	2.4	2.4	2.4
	Normal weight(18.5 - 22.9)	280	56.0	56.0	58.4
	Overweight(23.0 - 24.9)	149	29.8	29.8	88.2
	Obese I(25.0 - 29.9)	58	11.6	11.6	99.8
	Obese II(>=30.0)	1	.2	.2	100.0
	Total	500	100.0	100.0	

Table 4, depict BMI status of students in the study. According to Asian population criteria largest proportion of students were categorized normal weight 280(56%), among all where 149 (29.8%) students were overweight the rest 59 were Obese containing 58 (11.6%) Obese grade I and 1 (0.2%) Obese Grade II and only 12 (2%) students were underweight

Table 5- Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	6.196[a]	8	.625	.598		
Likelihood Ratio	8.004	8	.433	.454		
Fisher's Exact Test	5.971			.680		
Linear-by-Linear Association	1.138[b]	1	.286	.309	.154	.022
N of Valid Cases	500					

a. 5 cells (33.3%) have expected count less than 5. The minimum expected count is .10.

b. The standardized statistic is -1.067.

In Table 5, the association between BMI and cardiorespiratory endurance has been shown. Statistically non- significant(p 0.000; $P < 0.001$) difference was calculated by fisher's exact test (0.680) as more normal weighted students had high CRE (280; 56%)among all contrary to 58(11.6%) obese level I having low and 1 (0.2%)Obese II having very low CRE level

Table 6- Frequency distribution of BMI among students according to their cardiorespiratory endurance (CRE)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Underweight(<18.5)	12	1862.50	493.782	142.543	1548.77	2176.23	1130	2690
Normal weight(18.5 - 22.9)	280	1868.29	509.378	30.441	1808.36	1928.21	1000	2860
Overweight(23.0 - 24.9)	149	1808.05	417.609	34.212	1740.45	1875.66	1000	2550
Obese I(25.0 - 29.9)	58	1600.17	287.863	37.798	1524.48	1675.86	1050	2220
Obese II(>=30.0)	1	1180.00	.	.	.	.	1180	1180
Total	500	1817.72	468.470	20.951	1776.56	1858.88	1000	2860

Table 6 depicts Frequency distribution of BMI among students according to their cardiorespiratory endurance (CRE). Out of 500 respondents 12 underweight students are found to be with mean 1862.50, 280 normal weight are found to be with mean 1868.29, 149 are found to be with mean 1808.05, 58 are found to be with mean 1600.17 and 1 is found to be with mean 1180.00. The descriptive data is showing that there is a negative shift in cardiorespiratory fitness as the weight is increasing from normal weight to overweight and obesity level I and level II.

Figure 1- Cardiorespiratory endurance of students according to BMI.

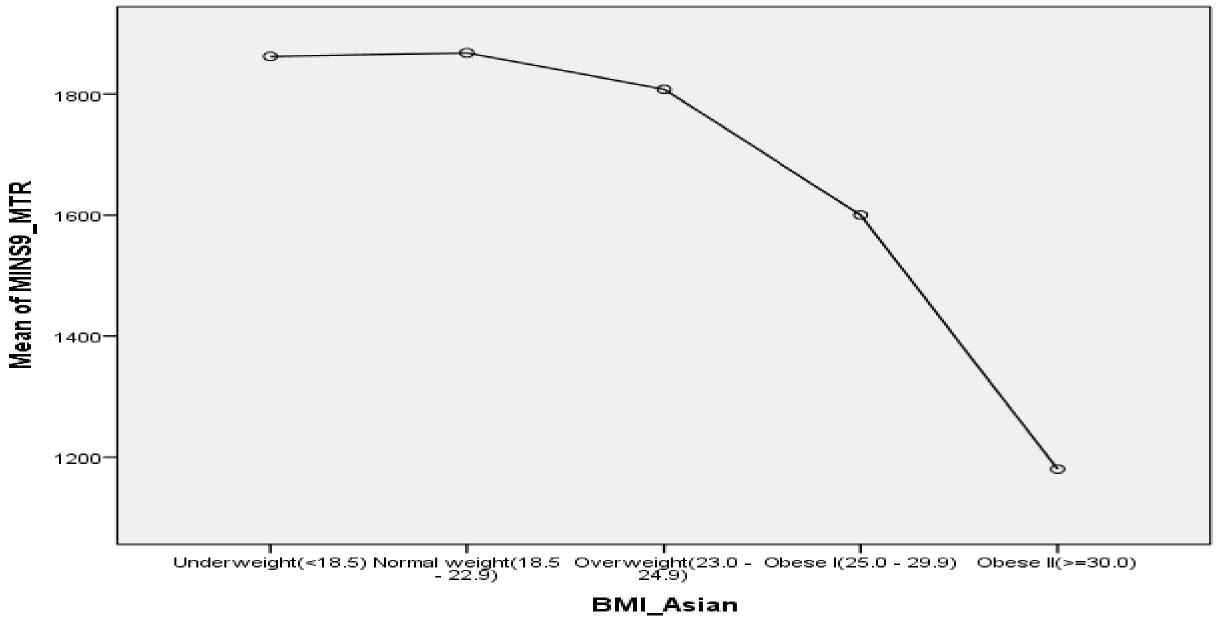

Figure 1, above illustrates Cardiorespiratory endurance of students according to BMI. Incline in mean BMI was seen with low levels of cardiorespiratroy endurance from 1862.50 meters to 1180 meters.

Table 7- Cardiorespiratory endurance (CRE) of male rural college students according to BMI

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3905564.811	4	976391.203	4.577	.001
Within Groups	105607035.989	495	213347.547		
Total	109512600.800	499			

Table 7 depicts results for test of variance Anova has been shown in Table 6, the value of ANOVA is found to be 4.577 which is significant at 5% level of significance, this shows that there is a significant difference in cardiorespiratory endurance of students according to BMI status.

Table 8- Paired mean difference of BMI according to cardiorespiratory endurance of students

(I) BMI_Asian	(J) BMI_Asian	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Underweight(<18.5)	Normal weight(18.5 - 22.9)	-5.786	136.165	1.000	-387.75	376.17
	Overweight(23.0 - 24.9)	54.446	138.603	.985	-334.35	443.25
	Obese I(25.0 - 29.9)	262.328	146.483	.362	-148.58	673.23
Normal weight(18.5 - 22.9)	Underweight(<18.5)	5.786	136.165	1.000	-376.17	387.75
	Overweight(23.0 - 24.9)	60.232	46.838	.648	-71.16	191.62
	Obese I(25.0 - 29.9)	268.113*	66.636	.001	81.19	455.04
Overweight(23.0 - 24.9)	Underweight(<18.5)	-54.446	138.603	.985	-443.25	334.35
	Normal weight(18.5 - 22.9)	-60.232	46.838	.648	-191.62	71.16
	Obese I(25.0 - 29.9)	207.881*	71.486	.039	7.35	408.41
Obese I(25.0 - 29.9)	Underweight(<18.5)	-262.328	146.483	.362	-673.23	148.58
	Normal weight(18.5 - 22.9)	-268.113*	66.636	.001	-455.04	-81.19
	Overweight(23.0 - 24.9)	-207.881*	71.486	.039	-408.41	-7.35

*. The mean difference is significant at the 0.05 level.

Table 8 depicts the significantly varying CRF differences between various BMI levels. Non-significant mean difference was seen for cardiorespiratory endurance of underweight and normal (p 1.000; p>0.05), underweight and overweight (p 0.985 ; p>0.05), students, normal weight and overweight (p 0.648 ; p>0.05) students. Whereas significant mean difference was seen for cardiorespiratory endurance of normal weight and Obese I (p .001 ; p>0.05) and between overweight and obese I (p .039 ; p>0.05), students at 5% level of significance. The researcher further analyzed that during early level of BMI category, the significant difference does not appear, whereas in middle levels of BMI criteria significant difference seems to be appear.

Table 9- Homogeneous Subsets

Scheffe

BMI_Asian	N	Subset for alpha = 0.05
		1
Obese I(25.0 - 29.9)	58	1600.17
Overweight(23.0 - 24.9)	149	1808.05
Underweight(<18.5)	12	1862.50
Normal weight(18.5 - 22.9)	280	1868.29
Sig.		.109

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 36.082.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

The above table displays means for groups in homogenous subsets. While grouping all the BMI levels into two subsets which include underweight, normal weight and overweight in subset 1 and overweight, obese I and obese II in subset 2. The researcher tries to find out the significant differences in these subsets. The table depicts that there is no significant difference between two subsets.

Table 10- Correlation between Cardiorespiratory endurance and BMI level.

		BMI	MINS9_MTR
BMI	Pearson Correlation	1	-.182**
	Sig. (2-tailed)		.000
	N	500	500
MINS9_MTR	Pearson Correlation	-.182**	1
	Sig. (2-tailed)	.000	
	N	500	500

**. Correlation is significant at the 0.01 level (2-tailed).

Table- 10 depicts the correlation between Cardiorespiratory endurance related to BMI level. It has been found that there is a significant negative mild correlation (-.182**)between Cardiorespiratory endurance and BMI at 1% level of significance.

Table 11- Mean cardiorespiratory scores among obese and not obese students

	Obese	N	Mean	Std. Deviation	Std. Error Mean
MINS9_MTR	Obese	59	1593.05	290.566	37.828
	Not Obese	441	1847.78	479.676	22.842

Table 12- Mean comparison of cardiorespiratory endurance between obese and not obese students

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
MINS9_MTR	Equal variances assumed	27.003	.000	-3.980	498	.000	-254.727	63.997	-380.463	-128.990
	Equal variances not assumed			-5.764	106.144	.000	-254.727	44.190	-342.336	-167.118

Table 12 depicts mean comparison of cardiorespiratory endurance between obese and not obese students. It was found that there is significant mean difference of cardiorespiratory endurance between obese and not obese students (P 0.000, $P < 0.05$)

Discussion

Numerous studies have indeed demonstrated a negative correlation between BMI and cardiorespiratory endurance, suggesting that individuals with higher BMI levels tend to exhibit poorer aerobic capacity. Excess adiposity, particularly visceral fat, is associated with a multitude of physiological changes that can impair cardiovascular function, including insulin resistance, chronic inflammation, dyslipidemia, and endothelial dysfunction. These metabolic alterations not only compromise cardiovascular health but also contribute to reduced exercise tolerance and impaired oxygen delivery to tissues during physical activity. Furthermore, obesity is frequently accompanied by a sedentary lifestyle, poor dietary habits, and comorbidities such as hypertension, diabetes, and dyslipidemia, all of which can further exacerbate the decline in cardiorespiratory fitness. Thus, our data clearly showed that with increased mean BMI level of the students there was a decline in the cardiorespiratory endurance among students. Therefore, at high levels of BMI, the disaster impact of low CRF's is shown with important lifestyle public health implications. It can be said that there is a high demand of making students aware regarding sedentary lifestyle outcomes and health related fitness programs must be a mandatory part of the students during their college years.

Conclusion

In conclusion, the relationship between BMI and cardiorespiratory endurance is complex and multifaceted, influenced by a myriad of genetic, physiological, behavioral, and environmental factors. While higher BMI levels are generally associated with poorer cardiorespiratory fitness, this association is not deterministic, and numerous exceptions exist. Recognizing the limitations of BMI as a standalone measure of health and fitness is crucial, and efforts to improve cardiorespiratory endurance should encompass a holistic approach that addresses lifestyle factors, body composition, and individual variability. As we delve deeper into the intricate interplay between BMI and cardiorespiratory endurance, we gain valuable insights into the complex dynamics of human physiology and the multifaceted nature of health and fitness.

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