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Interplay Between Physical Activity, Dietary Patterns, and Lipid Profiles in Prehypertensive Young Adults

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Author`s Contribution

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A B S T R A C T

Background: Non-communicable diseases (NCDs) now account for the majority of global deaths, with cardiovascular diseases such as heart attacks and strokes being the most prevalent. These conditions are driven by modifiable metabolic risk factors, including prehypertension, dyslipidemia, obesity, and elevated triglycerides, which often develop silently in young adults. Fortunately, lifestyle changes particularly adopting healthier dietary patterns and engaging in regular physical activity can effectively lower blood pressure and improve lipid profiles, thereby reducing cardiovascular risk.

Objectives: This study therefore investigates how diet quality and exercise levels relate to cholesterol and triglyceride profiles in 20–25-year-old university students with prehypertension or hypertension, aiming to identify key behaviors for early prevention.

Results: In a cohort of 100 university students (55% female, 45% male, aged 20–25), 49% were normotensive, 39% prehypertensive, and 12% hypertensive. Mean BMI was 22.02 ± 3.68 kg/m²; 64% had normal BMI, 17% were overweight, 3% obese, and 16% underweight. Cholesterol levels were desirable in 55%, borderline in 24%, and high in 21%, while 78% had normal triglycerides. Physical activity levels were low, with 58% minimally active, 13% highly active, and 29% inactive. BMI positively correlated with blood pressure ($r = 0.492$, $p < 0.001$) and inversely with physical activity ($r = –0.220$, $p = 0.028$). Physical activity also was negatively correlated with blood pressure ($r = –0.247$, $p = 0.013$). No significant correlations were found between BMI or physical activity and lipid levels. Blood pressure correlated modestly with cholesterol ($r = 0.277$, $p = 0.005$), while cholesterol and triglycerides showed a moderate inverse correlation ($r = –0.322$, $p = 0.001$). Healthier diets were associated with improved blood pressure and lipid profiles, though BMI links were less clear. These findings underscore the importance of integrated lifestyle approaches in managing cardiometabolic risk among young adults.

Conclusion: This study underscores the critical role of lifestyle modification—specifically healthier diets and increased physical activity—in curbing early cardiometabolic risk among young adults. By highlighting modifiable behaviors linked to blood pressure and lipid regulation, it provides actionable targets for university health programs. Ultimately, these findings support the implementation of campus-based wellness initiatives to prevent progression to overt cardiovascular disease.

Keywords: Prehypertension, Body Mass Index, Blood Pressure, Cholesterol, Triglycerides, Cardiovascular diseases, lifestyle interventions, Dietary Habits.

Introduction

Non-communicable diseases (NCDs) are chronic illnesses that are not transmitted from person to person and develop over long periods, significantly contributing to global morbidity and mortality. The primary categories of NCDs include cardiovascular diseases (CVDs), cancers, chronic respiratory diseases, and diabetes.[1] According to the WHO, NCDs are responsible for approximately 74% of all global deaths, with CVDs accounting for the highest proportion at around 17.9 million deaths annually.[2] In Pakistan, the burden of NCDs is equally alarming, contributing to 58% of total deaths, with heart diseases being the leading cause.[3] Cardiovascular diseases are the most prevalent form of NCDs worldwide and remain the

leading cause of death and disability. Globally, about 523 million people were living with CVDs in 2019, and approximately 18.6 million died from these conditions.[4] In Pakistan, ischemic heart disease alone is responsible for more than 16% of all deaths, while stroke contributes to around 9%.[5]

The rising trend of CVDs can largely be attributed to modifiable metabolic risk factors such as hypertension, dyslipidemia (abnormal cholesterol levels), obesity, and hypertriglyceridemia. These factors are closely associated with a cluster of conditions known as metabolic syndrome, which significantly elevate the risk of heart attacks and strokes.6 Prehypertension represents an early warning stage in the development of hypertension. Defined as systolic blood pressure between 120–139 mm Hg or diastolic between 80–89 mm Hg, prehypertension does not yet meet the criteria for hypertension but significantly increases the likelihood of its progression if left unmanaged.[7]

The pathophysiological transition from prehypertension to hypertension is often mediated by endothelial dysfunction, oxidative stress, and increased arterial stiffness. Once established, hypertension exerts continuous stress on the vasculature, accelerating the development of atherosclerotic plaques and increasing the risk of cardiovascular events. Hyper-cholesterolemia and hyper-triglyceridemia further compound the cardiovascular burden when coexisting with hypertension. Excess low-density lipoprotein (LDL) cholesterol infiltrates the endothelium, becomes oxidized, and triggers inflammatory responses that lead to plaque formation in arterial walls.[8]

Similarly, elevated triglyceride levels contribute to vascular inflammation, increased production of reactive oxygen species, and impaired nitric oxide-mediated vasodilation, all of which elevate blood pressure and compromise vascular health. Angiotensin II, a potent vasoconstrictor within the renin-angiotensin-aldosterone system (RAAS), plays a pivotal role in this mechanism by promoting sodium retention and systemic vasoconstriction. Dyslipidemia enhances the effects of Angiotensin II, thereby worsening hypertension and expediting atherosclerosis.[11]

In this context, lifestyle interventions such as physical activity and dietary modification emerge as essential strategies to mitigate cardiovascular risk. Physical activity improves vascular compliance, enhances endothelial function, and modulates autonomic regulation by reducing sympathetic activity and increasing parasympathetic tone.[12] It also positively affects lipid metabolism by increasing high-density lipoprotein (HDL) cholesterol and decreasing LDL cholesterol and triglycerides. Exercise-induced shear stress stimulates nitric oxide release, improving arterial dilation and reducing systemic vascular resistance, leading to lower blood pressure.[13]

Nutritional choices have a profound impact on both lipid profiles and blood pressure levels. Diets rich in fruits, vegetables, whole grains, lean protein, and healthy fats, such as the DASH and Mediterranean diets, have been shown to significantly reduce blood pressure and cholesterol levels. Reducing intake of sodium, saturated fats, and added sugars helps decrease LDL cholesterol and prevents triglyceride accumulation, which is crucial for vascular health.[14,15] The synergistic effect of a healthy diet and regular physical activity goes beyond individual metabolic improvements. Together, they reduce systemic inflammation, lower insulin resistance, decrease oxidative stress, and prevent endothelial dysfunction—all of which are central to the pathogenesis of hypertension and CVDs.[16] Conversely, a sedentary lifestyle and poor dietary habits contribute to obesity, metabolic syndrome, and a heightened inflammatory state, which collectively exacerbate cardiovascular risk.

Although numerous studies have explored hypertension and its associated risk factors, our study fills a critical gap by simultaneously examining the interrelationships between multiple variables—such as lipid levels, BMI, dietary patterns, and physical activity. Moreover, this investigation is unique in focusing on a young adult population (aged 20–25), a group often overlooked in cardiometabolic risk research.

Materials and Methods

This study utilized a cross-sectional design to examine the relationship between physical activity, dietary habits, and lipid profiles (cholesterol and triglycerides) in university students aged 20 to 25 years at the University of Management and Technology (UMT), Lahore. The study sample consisted of 100 participants who voluntarily enrolled by providing blood samples and completing the necessary questionnaires. The inclusion criteria for the study were male and female students aged between 20 and 25 years. Participants were excluded from the study if they met any of the following conditions: smokers, pregnant women, individuals taking antihypertensive medications, or those with a history of cardiovascular diseases, tuberculosis, renal disorders, tumors, thyroid or liver dysfunction, infectious diseases, or diabetes managed with insulin or other antidiabetic drugs.

Body Mass Index (BMI) was measured using the BF 508 Body Composition Monitor, which utilizes bioelectrical impedance to provide accurate body fat analysis. Blood pressure was assessed using the ABPM50 Ambulatory Blood Pressure Monitor to ensure reliable and continuous measurements of blood pressure. Dietary intake was assessed using a validated diet questionnaire, which scored participants based on the quality and frequency of their food consumption, including oil

type and salt usage. Physical activity levels were determined using the International Physical Activity Questionnaire (IPAQ), categorizing participants into three levels: inactive (below the minimum physical activity requirement), minimally active (≥600 MET-min/week), and highly active (HEPA active) (≥1500–3000 MET-min/week).

Biochemical assessment of total cholesterol and triglyceride levels was performed using commercially available enzymatic colorimetric kits via spectrophotometry for precise quantification. For data analysis, Pearson correlation tests were applied to evaluate the relationships between physical activity, dietary habits, cholesterol, triglyceride levels, and blood pressure. Cross-tabulations were also used to explore the association between categorical variables and identify patterns in the data. All statistical analyses were conducted using SPSS software (version 25), providing an in-depth understanding of the relationships between the variables who declined to participate in the research were excluded from the study. Data collected from the questionnaire was subjected to statistical analysis using the Statistical Package for the Social Sciences (SPSS) software- version 25, providing an in-depth understanding of the relationships between the variables.

Results

Females made up 55% (n=55) of the 100 participants, with males making up the remaining 45% (n=45). Nearly half (49%, n=49) had normal blood pressure (<120/80 mm Hg), while 39% (n=39) were prehypertensive (120–139/80–89 mm Hg) and 12% (n=12) hypertensive (≥140/90 mm Hg). The mean BMI was 22.02 ± 3.68 kg/m²: 64% (n=64) fell within the normal range (18.5–24.9 kg/m²), 17% (n=17) were overweight (25–29.9 kg/m²), 3% (n=3) obese (≥30 kg/m²), and 16% (n=16) underweight (<18.5 kg/m²). Lipid profiles showed 55% with normal cholesterol, 24% borderline, and 21% high, while 78% had normal triglycerides, 8% borderline, and 14% elevated. Physical activity levels (IPAQ) classified 58% as minimally active (≥600 MET-min/week), 13% as HEPA active (≥1500 MET-min/week), and 29% as inactive (<600 MET-min/week) (Table I).

Table II shows the Pearson correlation coefficients among Body Mass Index (BMI), MET value, blood pressure (B.P.), cholesterol, and triglycerides, emphasizing the connections between these variables in the research. There is a moderate positive correlation between BMI and blood pressure ($r = 0.492$, $p < 0.001$), suggesting that as BMI increases, blood pressure tends to rise as well, with statistical significance at the 0.01 level. Conversely, the correlation between BMI and MET value is weak and negative ($r = -0.220$, $p = 0.028$). This indicates that higher levels of physical activity (as indicated by MET) are linked to a lower BMI. The correlation holds statistical significance at the 0.05 level. The correlations between BMI and cholesterol ($r = 0.022$, $p = 0.828$) as well as between BMI and triglycerides ($r = 0.056$, $p = 0.579$) are very weak and non-significant, suggesting that there is no meaningful connection between BMI and these lipid markers. The MET value and blood pressure show a weak negative correlation ($r = -0.247$, $p = 0.013$), indicating that increased levels of physical activity are linked to lower blood pressure. The correlation holds statistical significance at the 0.05 level.

Table I: Distribution of Gender, Blood pressure, BMI, Cholesterol, Triglyceride Levels, and Physical Activity among Study Participants.

Category	Subcategory	N	%
Gender Distribution	Female	55	55%
	Male	45	45%
Blood Pressure	Normal (<120/80 mmHg)	49	49%
	Prehypertensive (120–139/80–89 mmHg)	39	39%
	Hypertensive (≥140/90 mmHg)	12	12%
BMI	Normal (18.5–24.9 kg/m²)	64	64%
	Overweight (25–29.9 kg/m²)	17	17%
	Obese (≥30 kg/m²)	3	3%
	Underweight (<18.5 kg/m²)	16	16%
Cholesterol	Normal	55	55%
	Borderline	24	24%
	High	21	21%
Triglyceride	Normal	78	78%
	Borderline	8	8%
	High	14	14%
Physical Activity (IPAQ)	Minimally Active (≥600 MET-min/week)	58	58%
	HEPA Active (≥1500–3000 MET-min/week)	13	13%
	Inactive (<600 MET-min/week)	29	29%

The MET value showed weak, non-significant correlations with cholesterol ($r = 0.159$, $p = 0.114$) and triglycerides ($r = -0.112$, $p = 0.266$), suggesting that there are no significant relationships with these variables. A moderate positive correlation exists between blood pressure and cholesterol ($r = 0.277$, $p = 0.005$), indicating that individuals with higher blood pressure tend to have higher cholesterol levels, a finding that is statistically significant at the 0.01 level. The correlation between blood pressure and triglycerides is very weak and non-significant ($r = 0.079$, $p = 0.435$), suggesting that there is no significant

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Table II: Pearson Correlation Matrix Among BMI, MET Values, Blood Pressure, Cholesterol, and Triglycerides.

		BMI (Kg/m2)	MET value	B.P (mmHg)	Cholesterol (mg/dl)	Triglycerides(mg/dl)
BMI (Kg/m2)	Pearson Correlation	1	-.220*	.492**	.022	.056
	Sig. (2-tailed)		.028	.000	.828	.579
MET value	Pearson Correlation	-.220*	1	-.247*	.159	-.112
	Sig. (2-tailed)	.028		.013	.114	.266
S.B.p (mmHg)	Pearson Correlation	.492**	-.247*	1	.277**	.079
	Sig. (2-tailed)	.000	.013		.005	.435
Cholesterol(mg/dl)	Pearson Correlation	.022	.159	.277**	1	-.322**
	Sig. (2-tailed)	.828	.114	.005		.001
Triglycerides(mg/dl)	Pearson Correlation	.056	-.112	.079	-.322**	1
	Sig. (2-tailed)	.579	.266	.435	.001	

association. Lastly, a moderate inverse correlation between cholesterol and triglycerides is noted (r = -0.322, p = 0.001). This indicates that elevated cholesterol levels are linked to reduced triglyceride levels, with the correlation being statistically significant at the 0.01 level.

Dietary patterns were assessed through five key questions covering daily servings of fruits and vegetables, monthly frequency of fast food consumption, intake of sugary beverages, type of cooking oil used, and the habit of adding extra salt to food. Each response was assigned a score, with healthier choices awarded higher points and unhealthy options receiving lower scores. The total dietary score for each participant was calculated by summing the scores from all five items. A higher total score indicated a healthier dietary pattern, whereas a lower score reflected poor dietary habits. The percentage distribution of participants based on their dietary habit scores is illustrated in Figure 1.

Figure 1. Percentage Distribution of Dietary Habits Scores.

Low dietary scores (Unhealthy diets) show high hypertension/prehypertension prevalence while high dietary scores (healthy diets) generally have more Normal BP. This relationship indicates a potential inverse association between healthier dietary habits and the prevalence of elevated blood pressure.

Lower scores show varied BMI, with Normal being common. As scores increase, Overweight and Obesity become more prevalent up to a score of 5. Higher scores (6-8) show a shift back towards Normal, with a small Obesity peak at 7. The healthiest scores (9-10) have low representation, mainly Normal. This suggests a complex link between diet and BMI, with healthier diets not consistently ensuring normal BMI.

Unhealthy diets (lower scores) show a mix of Borderline and High cholesterol. As dietary health improves (higher scores), Normal cholesterol becomes increasingly prevalent, peaking at scores 7 and 8. High cholesterol is less common with healthier diets, while Borderline levels show no clear trend. This suggests healthier diets are generally associated with normal cholesterol levels.

Unhealthy diets (lower scores) present a mix of Borderline and High triglycerides, though Normal levels are also present. As dietary health improves (higher scores), Normal triglyceride levels become dominant, peaking at scores 7 and 8. High triglycerides are less frequent with healthier diets, while Borderline levels remain relatively low across the dietary spectrum. This suggests a positive association between healthier dietary habits and the maintenance of normal triglyceride levels.

Discussion

Our study revealed that 39% of participants were prehypertensive and 12% hypertensive, rates that closely mirror findings in comparable university cohorts. A study reported by[17] reported prehypertension and hypertension prevalences of 37% and 10%, respectively, among Pakistani college students, suggesting that early blood-pressure elevations are pervasive even in young adults. Similarly, in a U.S. population of undergraduate students, study[18] observed prehypertension in 35% and hypertension in 11% of participants, underscoring the global nature of this trend. These consistent figures highlight that prehypertension and hypertension are not confined to older

populations but represent emerging issues in student health worldwide.

The positive correlation between BMI and blood pressure ($r = .492$, $p < .001$) in our cohort aligns with numerous epidemiological studies demonstrating that adiposity is a strong determinant of elevated blood pressure. Research by[19] found a comparable correlation coefficient ($r \approx .50$) between BMI and systolic blood pressure in a young adult sample, emphasizing the pathophysiological role of excess weight in vascular resistance. Moreover, the inverse relationship we observed between physical activity (measured in MET-minutes) and both BMI ($r = -.220$, $p = .028$) and blood pressure ($r = -.247$, $p = .013$) corroborates the meta-analysis[19], which documented that moderate to vigorous exercise reduces systolic blood pressure by approximately 4–6 mm Hg and contributes to weight management. This reinforces exercise as a critical modifiable factor in cardiometabolic health among students. In contrast to the strong BMI–blood pressure associations, we found no significant correlation between BMI and lipid markers—cholesterol ($r = .022$, $p = .828$) or triglycerides ($r = .056$, $p = .579$). A similar absence of direct BMI-lipid associations in young adults was reported by[20] (2020), who noted that while overweight status correlated with dyslipidemia risk in older populations, this relationship was attenuated in younger cohorts, possibly due to shorter exposure duration to excess adiposity. Instead, our data suggest that dietary quality may exert a more immediate influence on lipid profiles. Participants with healthier dietary scores exhibited markedly lower rates of high cholesterol and hypertriglyceridemia, echoing findings who reported that adherence to a Mediterranean diet reduced LDL cholesterol by 13% and triglycerides by 17% within months, independent of weight change.[21]

Our lipid-profile prevalence's—21% high cholesterol and 14% hypertriglyceridemia—also align with international literature. Study by[22] revealed dyslipidemia rates of 15–25% in U.S. Hispanic/Latino university students, while research documented hypertriglyceridemia in roughly 12% of Korean undergraduates.[23] The similarity of these figures across diverse ethnic and regional settings suggests that lifestyle factors common to university environments—such as irregular meal patterns, high processed-food consumption, and sedentary behavior—may drive early lipid abnormalities. Notably, our observation of a moderate inverse correlation between cholesterol and triglycerides ($r = -.322$, $p = .001$) is somewhat counterintuitive but has precedence;[24] described that in certain young populations, isolated hypercholesterolemia can occur without concurrent hypertriglyceridemia, reflecting distinct metabolic pathways influenced by dietary fat quality and genetic factors.

The weak and non-significant correlations between physical activity and lipid levels in our study (cholesterol $r = .159$, $p = .114$; triglycerides $r = -.112$, $p = .266$) contrast with some intervention trials that demonstrate lipid improvements with exercise.[25] However, study by[26] noted that in free-living young adults, self-reported physical activity often lacks sufficient intensity or duration to elicit measurable lipid changes, suggesting that structured exercise programs may be necessary to impact lipids significantly. This discrepancy underscores the importance of not only promoting physical activity but also ensuring that students engage in exercise of adequate intensity.

Overall, our findings are consonant with extant literature indicating that university students exhibit early signs of cardiometabolic risk, with adiposity and sedentary behavior primarily impacting blood pressure, whereas dietary habits more directly affect lipid profiles. The consistency of our prevalence rates and correlation patterns with studies from Pakistan, the United States, and East Asia attests to the universality of these relationships in young adult populations. These parallels underscore the need for targeted health promotion in higher-education settings to address modifiable risk factors before they solidify into chronic disease.

Conclusions

This cross-sectional study of 100 Pakistani university students aged 20–25 revealed that 39% were prehypertensive and 12% hypertensive, while 20% exhibited overweight or obesity. Dyslipidemia was present in 21% of participants for cholesterol and 14% for triglycerides. Physical activity demonstrated significant inverse correlations with both BMI and blood pressure, and BMI correlated positively with blood pressure.

Importantly, dietary quality showed strong associations with cardiometabolic markers: healthier diets corresponded to lower prevalence of elevated blood pressure, high cholesterol, and hypertriglyceridemia. These findings highlight that modifiable lifestyle factors—particularly balanced nutrition and regular exercise—are critical determinants of early cardiometabolic risk among young adults. Implementing targeted interventions in university environments to promote healthy dietary practices and increase physical activity may effectively mitigate progression toward overt hypertension and dyslipidemia, ultimately reducing the long-term burden of cardiovascular disease in this vulnerable population.

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