ORIGINAL ARTICLE

# Prevalence of Hypertension in Young Adults in Punjab

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## Abstract

**Introduction:** India has shown dramatic increase in noncommunicable diseases (NCDs), so much so that about 70% of the overall mortality is estimated to be because of NCDs. Young adults <35 years of age constitute 65%, a significant section of Indian population, but there is paucity of studies exploring prevalence of HTN among young adults in India, especially in Punjab. So, the present study was conducted to know the prevalence of HTN among young adults in Punjab.

**Materials and methods:** This observational study was conducted as part of a global blood pressure (BP) screening program, after approval from Institutional Ethics Committee. Subjects of 18–80 years were included after verbal informed consent. Data obtained was analyzed as per the standard statistical method, and Chi-squared test was applied.

**Results:** A total of 24,685 participants completed the study including 43.5% young adults. The prevalence of HTN in young adults was 9.2 and 18.8% in older adults. About 71.8% hypertensive young adults were overweight or obese. Males demonstrated 16.7% prevalence of HTN as compared to 12.3% in females, whereas in young adults 28.4% females had HTN as compared to 26.6% males.

**Conclusion:** Present study documents increase in prevalence of HTN among young adults and its association with overweight and obesity necessitating initiation of HTN prevention and control strategies, especially focused on young adults.


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## Introduction

Over decades, India has shown progressive decline in the prevalence of communicable diseases (CDs) and dramatic increase in noncommunicable diseases (NCDs), such as diabetes mellitus (DM), hypertension (HTN), cardiovascular diseases (CVDs), and cancers, so much so that presently about 70% of the overall mortality is estimated to be because of NCDs.[1] In 2023, India surpassed China to become the most populous country in the world with an estimated population of over 1.4 billion people with 50% of the population under the age of 25 years; about 65% of the population was under 35 years of age, and 6.9% were over 65 years of age.[2,3] Population of Punjab is about 3.17 crores, and the youth constitutes 46.5% of the population.[4] A report by the Technical Group of the National Commission suggested that 33.7% population is between 20 and 39 years of age, and 29.1% population is between the age-group of 40 and 79 years in Punjab.[5] In India, states and regions differ widely in ethnic and religious composition, socioeconomic development, and dietary habits. The overall prevalence of NCDs in various regions of India also varies, thereby making documentation of regional data an utmost important subject in order to plan and implement NCDs prevention and management programs.[6]

Recent data suggests 35.5% overall weighted prevalence of HTN in India with a state-wise prevalence ranging from the lowest 24.3% in Meghalaya to the highest 51.8% in Punjab.[1,6]

The Fifth National Family Health Survey (NFHS-5) presented the most representative and comprehensive data on HTN epidemiology. It documented significant state-wise differences in the prevalence of HTN with the highest prevalence among females in Sikkim (34.5%) and Punjab (31.2%) and also among men in Sikkim (41.6%) and Punjab (37.7%). In India, higher prevalence of HTN at young age than North and South America and Europe has been documented.[7] A study documented 11.2% prevalence of HTN among the young adults; prevalence was more in men than women (20.5 vs 7.5%; $p < 0.001$), and no gender difference was observed in older adults.[8]

Young adults constitute a significant section of Indian population, but there is paucity of studies exploring the prevalence of HTN among young adults in India, especially in Punjab, a state with one of the highest prevalence of HTN. We report the prevalence of HTN among young adults who participated in a global blood pressure (BP) screening program, the May Measurement Month (MMM), an initiative of the International Society of Hypertension in year 2017–2019, 2021, and 2024. The May Measurement Month had to be deferred in 2020 due to the COVID-19.

### Aims and Objectives

To study the prevalence of HTN among young adults in Punjab.

## Materials and Methods

### Study Design and Participants

This observational study was conducted as part of a global BP screening program; the MMM, an initiative of International Society of Hypertension and the Indian Society of Hypertension. Our center was a part of this initiative in year 2017–2019, 2021, and 2024, conducted hospital-based screening, and organized screening camps. The campaign was conducted from May 1 to May 31 every year and sometimes extended to the month of June and July also. Institutional Ethics Committee approved the project vide letter number: 3/2017/3.4.2017. All subjects between the ages of 18 and 80 years were included in the study after verbal informed consent approved by the Institutional Ethics Committee. Those who did not give verbal informed consent were not included in the study. Subjects were recruited through convenience sampling.

### Blood Pressure Measurement

Measurement of BP was done, according to the standard protocol, preferably from the left arm, in comfortably seated position with a back rest, uncrossed legs with feet touching the ground, and after a 5-minute rest. Three readings of BP were taken, 1 minute apart, the mean of second and third BP measurement was considered for the study. OMRON BP monitors were used for the screening campaign.

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### Definition of Hypertension

Hypertension was defined, according to the Indian Hypertension Guidelines as BP of ≥140/90 mm Hg, isolated systolic HTN as BP of ≥140 mm Hg and isolated diastolic HTN as BP of ≥90 mm Hg.[9,10]

### Definition of Young Adults

The American College of Cardiology (ACC) and the American Heart Association (AHA) often classify 18–39 years as a distinct age-group for studies on HTN and early identification of cardiovascular (CV) risk.[11,12] In Indian context, public health studies and studies on HTN generally defined young adults as 20–40 years or 18–40 years of age-group.[8]

Hypertension in young has been defined as presence of HTN in patients <40 years of age.[13] So, in our study we have considered 18–40 years age-group to study prevalence of HTN in young adults.

### Body Mass Index

Weight was measured in kilograms using standard weighing machine; height was measured using standard measuring scale, and body mass index (BMI) was calculated by using the formula = weight (kg)/height ($m^2$).

The World Health Organization and several other guidelines categorize BMI in Asian population with a BMI of <18.5 kg/$m^2$ as underweight, 18.5–22.9 kg/$m^2$ as normal weight, 23.0–27.5 kg/$m^2$ as overweight, and ≥27.5 kg/$m^2$ as obese. In the present study for convenience, BMI was categorized in three categories of underweight as BMI of <18.5 kg/$m^2$, normal weight as BMI of 18.5–22.9 kg/$m^2$, and overweight and obese as BMI of >23.0 kg/$m^2$.[14,15]

### Heart Rate

The AHA, all guidelines, and textbooks define normal sinus heart rate (HR) as between 60 and 100 beats per minute (bpm) and bradycardia if HR is <60 bpm and tachycardia if HR is >100 bpm.[16,17]

### Statistical Analysis

The prevalence of HTN, according to Indian Hypertension Guidelines, was calculated for the study population, and prevalence was compared. Data obtained was analyzed as per the standard statistical method. Frequency and percentages were calculated, and Chi-squared test was applied to find out their association and significance.

## Results

### Baseline Characteristics of Study Population

Among the total study population of 24,685 participants, young adults (18–40 years) constituted 43.5%. Females constituted a slightly higher proportion of the young adult group (53.0%) compared to males (47.0%), in contrast with the older age-group (41–80 years), where males constituted a higher proportion (Table 1).

Young adults had a statistically significant higher prevalence of normal BMI (30.9%) compared to older adults (21.7%). However, the majority of young adults (59.7%) were overweight or obese (BMI ≥23 kg/$m^2$), indicating a significant burden of overweight or obesity even in younger population cohort. Heart rate measurements were predominantly within the normal range (60–100 bpm) in young adults (94.0%).

### Prevalence of Hypertension in Young Adults

The prevalence of HTN in young adults was 9.2%, significantly lower than the 18.8% in older adults (Table 2). Among hypertensive young adults, males accounted for 58.4% of cases, while females accounted for 41.6%, though this gender difference was not statistically significant. A significant proportion of hypertensive young adults (71.8%) were overweight or obese (BMI >23 kg/$m^2$), underscoring the strong association between excess weight and HTN in this age-group ($p < 0.0001$). Normal BMI (18.5–22.9 kg/$m^2$) subjects accounted for 22.2% of HTN cases among young adults, indicating that HTN is not exclusively confined to those with higher BMI levels (Table 2). In hypertensive young adults, HR was predominantly normal (86.6%; Table 2), while a minority of young hypertensive patients had tachycardia (12.8%). Similar pattern was seen in the older hypertensive patients showing 90.0% subjects had normal HR, and 9% had tachycardia.

### Prevalence of Hypertension among Gender Groups

Table 3 highlights gender-specific differences in the prevalence of HTN. Overall, males demonstrated a statistically significant higher prevalence of HTN (16.7%) as compared to females (12.3%, $p = 0.0003$). Among young adults (18–40 years), females had a marginally higher prevalence of HTN (28.4%) than males (26.6%, $p = 0.5322$). Conversely, in older adults (41–80 years), males exhibited a slightly higher prevalence (73.4%) compared to females (71.6%, $p = 0.3121$). These findings suggest insignificant gender differences in young adults but a trend toward statistically significant higher prevalence of HTN in older males. In overweight or obese BMI group (>23 kg/$m^2$), the prevalence of HTN was more in total study population (77.2%), males (77.9%) as well as females (76.2%) as compared to normal/underweight weight population.

### Systolic and Diastolic Hypertension in Young Adults

Systolic HTN [systolic blood pressure (SBP) ≥140 mm Hg] was observed in 15.8% of young adults, compared to 32.0% in older adults ($p < 0.0001$; Table 4). Diastolic HTN [diastolic blood pressure (DBP) ≥90 mm Hg] was

**Table 1:** Baseline characteristics of study population, according to gender, BMI, and HR among age-groups [% (*n*)]

| *Characteristic factors* | | *Age-groups* | | | *95% CI* | *p* |
|---|---|---|---|---|---|---|
| | | *18–80 years* | *18–40 years* | *41–80 years* | | |
| Study population | | 24,685 | 43.5 (10,732) | 56.5 (13,953) | 11.7497–14.2444% | <0.0001 S |
| Gender | Male | 52.6 (12,996) | 47.0 (5,043) | 57.0 (7,953) | 8.2413–11.7509% | <0.0001 S |
| | Females | 47.4 (11,689) | 53.0 (5,689) | 43.0 (6,000) | 8.1929–11.7980% | <0.0001 S |
| BMI, kg/$m^2$ | <18.5 | 6.2 (1,516) | 9.6 (1,031) | 3.5 (485) | 3.4794–8.4469% | <0.0001 S |
| | 18.5–22.9 | 25.6 (6,324) | 30.9 (3,296) | 21.7 (3,028) | 6.8395–11.1444% | <0.0001 S |
| | ≥23 | 68.2 (16,845) | 59.7 (6,405) | 74.8 (10,440) | 13.6382–16.5610% | <0.0001 S |
| HR/mts | <60 | 0.7 (181) | 0.7 (75) | 0.7 (106) | −5.4612 to 4.0965% | = 1.0000 NS |
| | 60–100 | 94.1 (23,230) | 94.0 (10,089) | 94.2 (13,141) | −0.4083 to 0.8168% | = 0.5209 NS |
| | >100 | 5.2 (1,274) | 5.3 (570) | 5.1 (704) | −2.3593 to 2.6443% | = 0.8732 NS |

BMI, body mass index; CI, confidence interval; HR/mts, heart rate/minute; NS, statistically not significant *p*-value; S, statistically significant *p*-value

**Table 2:** Prevalence of HTN (≥140/90 mm Hg) in study population, according to gender, BMI, and HR among age-groups [% (*n*)]

| *Characteristic factors* | | *Age-groups* | | | *95% CI* | *p* |
|---|---|---|---|---|---|---|
| | | *18–80 years* | *18–40 years* | *41–80 years* | | |
| Study population | | 24,685 | 43.5 (10,732) | 56.5 (13,953) | 11.7497–14.2444% | <0.0001 S |
| Total ≥140/90 mm Hg | | 14.6 (3,611) | 9.2 (986) | 18.8 (2,625) | 7.1581–11.8563% | <0.0001 S |
| Gender | Male | 60.1 (2,169) | 58.4 (576) | 60.7 (1,593) | −2.3388 to 7.0079% | = 0.3342 NS |
| | Females | 39.9 (1,442) | 41.6 (410) | 39.3 (1,032) | −3.2596 to 7.9496% | = 0.4213 NS |
| BMI, kg/m$^2$ | <18.5 | 3.5 (127) | 6.0 (59) | 2.6 (68) | −4.5525 to 12.7503% | = 0.3415 NS |
| | 18.5–22.9 | 19.3 (697) | 22.2 (219) | 18.2 (478) | −2.2235 to 10.7623% | = 0.2159 NS |
| | ≥23 | 77.2 (2,787) | 71.8 (708) | 79.2 (2,079) | 3.7383–11.2195% | <0.0001 S |
| HR/mts | <60 | 0.8 (31) | 0.6 (6) | 1.0 (25) | −38.7708 to 14.4077% | = 0.9279 NS |
| | 60–100 | 89.1 (3,217) | 86.6 (854) | 90.0 (2,363) | 0.9246–6.1040% | = 0.0063 S |
| | >100 | 10.1 (363) | 12.8 (126) | 9.0 (237) | −2.6256 to 11.3788% | = 0.2579 NS |

BMI, body mass index; CI, confidence interval; HR/mts, heart rate/minute; NS, statistically not significant *p*-value; S, statistically significant *p*-value

**Table 3:** Prevalence of HTN (≥140/90 mm Hg), according to age groups, BMI, and HR among gender groups in study population [% (*n*)]

| *Characteristic factors* | | *Gender groups* | | | *95% CI* | *p* |
|---|---|---|---|---|---|---|
| | | *Total* | *Male* | *Females* | | |
| Study population | | 24,685 | 52.6 (12,996) | 47.4 (11,689) | 3.9515–6.4462% | <0.0001 S |
| Total ≥140/90 mm Hg | | 14.6 (3,611) | 16.7 (2,169) | 12.3 (1,442) | 2.0532–6.6798% | = 0.0003 S |
| Age-groups | 18–40 years | 27.3 (986) | 26.6 (576) | 28.4 (410) | −3.7956 to 7.5067% | = 0.5322 NS |
| | 41–80 years | 72.7 (2,625) | 73.4 (1,593) | 71.6 (1,032) | −1.6729 to 5.3289% | = 0.3121 NS |
| BMI, kg/m$^2$ | <18.5 | 3.5 (127) | 3.5 (76) | 3.5 (51) | −7.3235 to 9.4150% | = 1.0000 NS |
| | 18.5–22.9 | 19.3 (697) | 18.6 (404) | 20.3 (293) | −4.1634 to 7.7793% | = 0.5749 NS |
| | >23 | 77.2 (2,787) | 77.9 (1,689) | 76.2 (1,098) | −1.4694 to 4.9347% | = 0.2958 NS |
| HR/mts | <60 | 0.8 (31) | 0.9 (19) | 0.8 (12) | 24.5575–17.4959% | = 0.9770 NS |
| | 60–100 | 89.1 (3,217) | 88.8 (1,927) | 89.5 (1,290) | −1.5324 to 2.8524% | = 0.5328 NS |
| | >100 | 10.1 (363) | 10.3 (223) | 9.7 (140) | −6.2942 to 6.6818% | = 0.8535 NS |

BMI, body mass index; CI, confidence interval; HR/mts, heart rate/minute; NS, statistically not significant *p*-value; S, statistically significant *p*-value

present in 16.7% of young adults, compared to 26.7% in older adults ($p < 0.0001$). These findings suggest that isolated systolic HTN is less common than diastolic HTN in young adults, whereas in older age-groups systolic HTN was more common than diastolic HTN. Prevalence of systolic HTN was higher (71.9%) than diastolic HTN (70.2%) in overweight or obese BMI group among young adults, whereas prevalence of diastolic HTN (79.1%) was relatively high as compared to systolic HTN (77.9%) in overweight and obese BMI group in older adults.

Prevalence of systolic HTN was higher in young males (58.3%) as compared to young females (41.7%). Prevalence of diastolic HTN followed a similar trend with higher prevalence in young males (56.8%) as compared to young females (43.2%).

### Prevalence of Hypertension according to Heart Rate among Young Adults

Normal HR (60–100 bpm) was observed in 84.5% of systolic hypertensive young adults and 91.9% systolic hypertensive older adults, and the difference was statistically significant. Tachycardia (HR >100 bpm) was present in 14.4% of systolic hypertensive young adults, which was statistically and significantly higher than older systolic hypertensive adults (6.8%, $p = 0.0035$; Table 4). Bradycardia (HR <60 bpm) was uncommon in both young and old adults with HTN and showed no significant association with age or gender groups.

In diastolic hypertensive patients, normal HR (60–100 bpm) was observed in 85.4% of young adults, statistically and significantly less as compared to 93.6% in older adults ($p < 0.0001$), while the trend reversed as it was seen in 14.1% of young adults, and 5.6% older adults showed tachycardia.

### Systolic and Diastolic Hypertension across Gender Groups

The analysis of HTN across gender groups is shown in Table 5. Among males, the prevalence of systolic HTN (SBP ≥140 mm Hg) was 28.4%, significantly higher than the 21.1% observed in females ($p < 0.0001$). Similarly, diastolic HTN (DBP ≥90 mm Hg) was more prevalent in males (24.9%) than females (19.2%; $p < 0.0001$).

## Discussion

### Hypertension in Young Adults: A Growing Concern

Present study underlines a substantial burden of HTN (≥140/90 mm Hg) in 9.2% of young adults (18–40 years) with notable links to overweight and obesity. Young adults had lower HTN prevalence rates than older adults, but the findings stress the importance of screening procedures and interventions at early stages to prevent long-term consequences on CV health.[18,19]

Present study shows that among the young hypertensive population, 71.8% were either overweight or obese, suggesting overweight/obesity as one of the important risk factors for high BP in young hypertensive population. In addition, this cohort had slightly more prevalence of diastolic HTN (16.7%) than systolic HTN (15.8%) which is contrary to older adults who had a higher level of systolic HTN. These findings of increased prevalence of HTN in young adults corroborates with the findings of several international and Indian studies so far which have reported the increasing prevalence of

**Table 4:** Prevalence of systolic HTN (≥140 mm Hg) and diastolic HTN (≥90 mm Hg) in study population, according to gender, BMI, and HR groups among age-groups [% (*n*)]

| *BP* | | *Systolic HTN ≥140 mm Hg* | | | *Diastolic HTN ≥90 mm Hg* | | |
|---|---|---|---|---|---|---|---|
| Age-groups | | 18–40 years | 41–80 years | 95% CI/*p* | 18–40 years | 41–80 years | 95% CI/*p* |
| Study population | | 10,732 | 13,953 | | 10,732 | 13,953 | |
| Total | | 15.8 (1,696) | 32.0 (4,462) | 13.9380–18.3598%<br><0.0001 S | 16.7 (1,762) | 26.7 (3,721) | 7.7108–12.2073%<br><0.0001 S |
| Gender groups | Males | 58.3 (989) | 60.6 (2,706) | −1.2569 to 5.8966%<br>= 0.2065 NS | 56.8 (1,000) | 60.0 (2,234) | −0.4636 to 6.8880%<br>= 0.0873 NS |
| | Females | 41.7 (707) | 39.4 (1,756) | −1.9586 to 6.6098%<br>= 0.2921 NS | 43.2 (762) | 40.0 (1,487) | −1.0877 to 7.5136%<br>= 0.1444 NS |
| BMI, kg/m$^2$ | <18.5 | 5.8 (98) | 3.5 (157) | −2.9296 to 9.0863%<br>= 0.3838 NS | 6.9 (121) | 2.6 (98) | −2.0001 to 10.5264%<br>= 0.1466 NS |
| | 18.5–22.9 | 22.3 (378) | 18.6 (830) | −1.0997 to 8.8157%<br>= 0.1344 NS | 22.9 (404) | 18.3 (680) | −0.3164 to 9.7259%<br>= 0.0673 NS |
| | ≥23 | 71.9 (1,220) | 77.9 (3,475) | 3.1729–8.9181%<br><0.0001 S | 70.2 (1,237) | 79.1 (2,943) | 5.9957–11.8748%<br>< 0.0001 S |
| HR/mts | <60 | 1.1 (19) | 1.3 (56) | −17.3295 to 7.6439%<br>= 0.9463 NS | 0.5 (9) | 0.8 (28) | −29.8192 to 12.9391%<br>= 0.9276 NS |
| | 60–100 | 84.5 (1,433) | 91.9 (4,101) | 5.4155–9.5210%<br><0.0001 S | 85.4 (1,504) | 93.6 (3,483) | 6.2990–10.2251%<br><0.0001 S |
| | >100 | 14.4 (244) | 6.8 (305) | 2.4634–13.0740%<br>= 0.0035 S | 14.1 (249) | 5.6 (210) | 3.0113–13.9226%<br>= 0.0028 S |

BP, blood pressure; BMI, body mass index; CI, confidence interval; HR/mts, heart rate/minute; NS, statistically not significant *p*-value; S, statistically significant *p*-value

**Table 5:** Prevalence of systolic HTN (≥140 mm Hg) and diastolic HTN (≥90 mm Hg) in study population according to age-groups, BMI, and HR groups among gender groups [% (*n*)]

| *BP* | | *Systolic HTN ≥140 mm Hg* | | | *Diastolic HTN ≥90 mm Hg* | | |
|---|---|---|---|---|---|---|---|
| Gender groups | | Males | Females | 95% CI/*p* | Males | Females | 95% CI/*p* |
| Study population | | 12,996 | 11,689 | | 12,996 | 11,689 | |
| Total | | 28.4 (3,695) | 21.1 (2,463) | 5.1116–9.4517%<br>*p* < 0.0001S | 24.9 (3,234) | 19.2 (2,249) | 3.4744–7.8884%<br>*p* < 0.0001 S |
| Age-groups | 18–40 years | 26.8 (989) | 28.1 (693) | −2.9967 to 5.6686%<br>*p* = 0.5561 NS | 30.9 (1,000) | 33.9 (762) | −1.3944 to 7.4224%<br>*p* = 0.1819 NS |
| | 41–80 years | 73.2 (2,706) | 71.9 (1,770) | −1.3598 to 3.9929%<br>*p* = 0.3399 NS | 69.1 (2,234) | 66.1 (1,487) | −0.0612 to 6.0852%<br>*p* = 0.0549 NS |
| BMI, kg/m$^2$ | <18.5 | 3.9 (143) | 4.5 (112) | −4.6291 to 6.5743%<br>*p* = 0.8122 NS | 3.9 (126) | 4.1 (93) | −5.3692 to 6.7617%<br>*p* = 0.9405 NS |
| | 18.5–22.9 | 19.0 (701) | 20.6 (507) | −2.9021 to 6.2277%<br>*p* = 0.4901 NS | 18.3 (592) | 21.9 (492) | −1.1700 to 8.4357%<br>*p* = 0.1398 NS |
| | ≥23 | 77.1 (2,851) | 74.9 (1,844) | −0.2899 to 4.7267%<br>*p* = 0.0837 NS | 77.8 (2,516) | 74.0 (1,664) | 1.1582–6.4776%<br>*p* = 0.0047 S |
| HR/mts | <60 | 1.5 (54) | 0.9 (21) | −15.4955 to 8.3619%<br>*p* = 0.8398 NS | 0.7 (22) | 0.7 (15) | −15.3465 to 20.7957%<br>*p* = 1.0000 NS |
| | 60–100 | 89.8 (3,320) | 89.9 (2,214) | −1.5504 to 1.7019%<br>*p* = 0.9040 NS | 90.8 (2,938) | 91.1 (2,049) | −1.3444 to 1.8960%<br>*p* = 0.7168 NS |
| | >100 | 8.7 (321) | 9.2 (228) | −4.2481 to 5.6679%<br>*p* = 0.8395 NS | 8.5 (274) | 8.2 (185) | −5.2821 to 5.3180%<br>*p* = 0.9095 NS |

BP, blood pressure; BMI, body mass index; CI, confidence interval; HR/mts, heart rate/minute; NS, statistically not significant *p*-value; S, statistically significant *p*-value

HTN among the younger populations because of lifestyle changes and urbanization.[12,20]

Hypertension has always been thought be associated with older age; however, presently it is becoming far more prevalent in younger populations which is a cause for concern. In the present study, young adults had a high prevalence of diastolic HTN (16.7%) and a significant burden of systolic HTN (15.8%), thus suggesting the advantage of early screening for prevention and management of HTN in the young adult demographic. The data also

revealed that diastolic HTN was more prevalent among the younger population as compared to the older age-group, where higher prevalence of systolic HTN was documented. These findings of more prevalence of diastolic HTN in young adults can be explained on the basis of vascular physiological variations in younger people as compared to older people, who have increased arterial toughening as well as systemic inflammation leading to increased prevalence of systolic HTN. While, in young individuals, a raised diastolic pressure could open a new set of complications as it would be the early sign of deterioration of vascular physiological system.[9,21,22]

Increasing prevalence of HTN including isolated systolic as well as isolated diastolic HTN in young adults poses specific challenges, such as paucity of healthcare services, lesser awareness about HTN, its risk factors, complications, and beliefs about their nonvulnerability to NCDs or chronic diseases which can lead to poor prevention, management, and control of HTN, exposing the young adult population to greater risk of CVD morbidity and mortality. Results of the present study suggest a focused need for public health interventions in this group, and the interventions should focus on education, lifestyle change, and routine monitoring of BP to fill these gaps.[12,22]

## Gender Differences in Hypertension

Statistically insignificant [$p = 0.5322$; not significant (NS)] difference was observed in gender comparison in the prevalence of HTN among young adults, with 26.6% prevalence of HTN among males and 28.4% among females. Systolic HTN appeared slightly higher (28.1%) among females than males (26.8%), while diastolic HTN showed an opposite trend, being more common among females (33.9%) than males (30.9%). Such an observation while not very significant, still accounts for the gender factors depending on generalized physiological and hormonal relations with BP mechanisms. Estrogen as a protective factor among women may turn out to be a contributor of these patterns.[23,24]

The gender gap was more apparent in elderly people, where males had a significantly higher rate of both systolic and diastolic HTN compared to females. This might be due to the postmenopausal hormonal changes in women and greater exposure to behavioral risk factors, such as smoking and alcohol consumption in men.[25,26]

## Body Mass Index and Hypertension in Young Adults

In the present study, overweight/obesity group showed a significant association with prevalence of HTN, with prevalence of HTN of 71.8% in overweight/obese (>23 kg/m$^2$) young adults as compared to normal BMI young adults who showed significantly higher prevalence of systolic (23.2%), and diastolic (21.9%) HTN. Overweight/obesity triggers several pathophysiological alterations, such as sympathetic activity, insulin resistance, and vascular dysfunction, all of which together lead to increased BP.[27] Since, HTN is also present in young adults with normal BMI (22.2%), this suggests contribution of other risk factors, such as genetic predisposition, stress, and diet.[28–30]

These findings emphasize the dire need for focused public health interventions, such as diet-related, physical activity-based weight management programs with behavior modifications. Weight management, along with control of obesity-induced HTN in young adults, is an important intervention for preventing long-term CV complications.[31,32]

## Heart Rate and Hypertension

The link between high HRs and HTN in young adults was another significant observation. Tachycardia (HR >100 bpm) occurred in 14.4% of systolic hypertensive and 14.1% of diastolic hypertensive young adults, which was substantially higher than older adults. High HRs may serve as a marker of additional CV stress, underlining the necessity for comprehensive HR evaluations in HTN management.[33]

## Comparisons with Existing Data

Results of the present study compare well with results of studies from the United States and China showing increasing prevalence of HTN, especially in young adult group.[34,35] Prevalence of HTN in young adults aged 18–44 years was documented by a US study from the year 2019 to 2022 to be 7.4, 6.9, 6.7, and 7.2%, respectively.[36] A study from an urban slum of Mumbai, Maharashtra, documented 12.2% of prevalence of HTN in young adults aged 20–40 years.[37] A study documented 17.7% prevalence of HTN in young adults aged 18–40 years including 18.8% among men and 15.2% among women from the North India.[38] Hypertension among young people is common, affecting one in eight adults aged between 20 and 40 years.[39] The prevalence of HTN was high even among young age individuals as observed in the HTN epidemiological study conducted in India.[21] The trends were attributed to common risk factors, such as dietary transitions, reduced physical activity, and increased urbanization.[40,41] For India, the high prevalence of HTN in young adults, along with resource constraints, underlines the need for tailored strategies that balance early diagnosis with healthcare system capacity.

## Public Health and Clinical Implications

The results of the present study will have considerable significance for health as well as the practice in India. India should initiate futuristic-targeted HTN prevention as well as control programs focusing on the young adults. This is important to arrest the rising trends of HTN and its complications. Such an initiative focusing on young adults would prevent increased prevalence of HTN in the future. Lifestyle modifications stressing on dietary control, physical workout, stress reduction, and other risk factor control should be included in the prevention and control programs. Young adults can also be involved in the technology-based solutions, such as mobile health applications that would provide more uptake and adherence to these interventions.[42] Monitoring HR in young adults might give useful information for HTN evaluation and detection efforts in clinical settings. Efforts should be made at the community level to serve marginalized regions in terms of access to care as well as treatment outcomes.

Generally, guidelines do not address the issues of HTN in young which is presently a growing concern in India as substantiated by the results of the present study. Given the high prevalence of HTN in young in the present study, India must focus on early and effective intervention for prevention, detection, and control of HTN to harvest immense benefits of reduction of morbidity and mortality in young adults. In the absence of quality studies and guidelines, doctors are leading the fight against HTN in young adults based only on clinical experience.[43]

## Limitations

The present study in spite of having surveyed a large number of subjects has several limitations. Firstly, the cross-sectional study design may show causal association between gender, overweight/obesity, and HTN. Secondly, convenience sampling method used in the present study may lead to selection bias and limit the generalizability of the results which is considered an important limitation. Third, limitation is the consideration of single-point BP measurement. In the present study, mean of second and third BP measurement was considered, but guidelines do not recommend diagnosis of HTN based on single-point BP measurement and that could result in increased or decreased prevalence of HTN by including transient HTN.[12] Future studies should consider the above-discussed

limitations through conducting longitudinal studies and including larger, randomized samples.

## Conclusion

Present study documents the increase in prevalence of HTN among young adults and its association with overweight and obesity. Prevalence of diastolic HTN in young population was observed as compared to increased prevalence of systolic HTN in older adults which signify age-related factors contributing to differences in the pathophysiology of HTN. Differences in HTN patterns among gender underscore the impact of hormonal and behavioral determinants.

The present study may suggest additional opportunities to curb increasing prevalence of HTN in young adults by improvement in the design and implementation of universal public health programs, such as routine screening and lifestyle modifications, including diet and exercise focusing on high-risk groups.

The present study suggests increasing HTN-related health concern among the young adults. Further studies must be done with more focus on longitudinal studies in order to fully understand HTN in young adults, its risk factors, possible prevention and management issues using modern technology to combat HTN, especially in young adults.

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