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CORRELATION OF BLOOD PRESSURE WITH PHYSICAL ACTIVITY AMONG ADULTS AT RAJASTHAN UNIVERSITY OF HEALTH SCIENCES, COLLEGE OF MEDICAL SCIENCES, JAIPUR

Ankita Tyagi, Sudhanshu Kacker, Neha Saboo, Munesh Kumar

Rajasthan University of Health Sciences, College of Medical Sciences, 302033, Sector 18, Kumbha Marg, Pratap Nagar, Jaipur, Rajasthan, India

ABSTRACT

Background. Hypertension and pre-hypertension are increasingly prevalent in India and contribute significantly to cardiovascular morbidity and mortality. Physical inactivity is a major modifiable risk factor influencing blood pressure regulation, particularly among young adults and healthcare populations.
Aim. To assess the prevalence of normotension, pre-hypertension, and hypertension and to evaluate the correlation between blood pressure and physical activity among adults aged 18–60 years at Rajasthan University of Health Sciences, College of Medical Sciences, Jaipur.
Materials and methods. A cross-sectional observational study was conducted among 700 participants. Blood pressure was measured using a standard mercury sphygmomanometer. Physical activity was assessed using the World Health Organization Global Physical Activity Questionnaire. Participants were categorized into inactive, moderately active, and vigorously active groups. Statistical analysis was performed using SPSS version 16.0.
Results. The prevalence of normotension, pre-hypertension, and hypertension was 65 %, 34.85 %, and 0.02 %, respectively. Nearly half of the participants (46.2 %) were physically inactive. Pre-hypertension was significantly more common among physically inactive individuals. Increased levels of physical activity were associated with lower mean systolic and diastolic blood pressure values.
Conclusion. Physical inactivity is strongly associated with elevated blood pressure. Early lifestyle modification with emphasis on regular physical activity can prevent progression from pre-hypertension to hypertension and reduce future cardiovascular risk.

Key words: *blood pressure, physical activity, pre-hypertension, Global Physical Activity Questionnaire (GPAQ), hypertension*

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КОРРЕЛЯЦИЯ АРТЕРИАЛЬНОГО ДАВЛЕНИЯ С ФИЗИЧЕСКОЙ АКТИВНОСТЬЮ СРЕДИ ВЗРОСЛЫХ В МЕДИЦИНСКОМ КОЛЛЕДЖЕ УНИВЕРСИТЕТА МЕДИЦИНСКИХ НАУК РАДЖАСТХАНА, ДЖАЙПУР

Тьяги А., Каккер С., Сабу Н., Кумар М.

Раджастханский университет медицинских наук, Колледж медицинских наук, 302033, Сектор 18, Кумбха Марг, Пратап Нагар, Джайпур, Раджастхан, Индия

АННОТАЦИЯ

Актуальность. Гипертония и предгипертония становятся всё более распространёнными в Индии и вносят значительный вклад в сердечно-сосудистую заболеваемость и смертность. Физическая неактивность является основным модифицируемым фактором риска, влияющим на регуляцию артериального давления, особенно среди молодых взрослых и населения, нуждающегося в медицинской помощи.

Цель. Оценить распространённость нормотонии, предгипертонии и гипертонии, а также оценить корреляцию между артериальным давлением и физической активностью среди взрослых в возрасте 18–60 лет в Медицинском колледже Университета медицинских наук Раджастхана, Джайпур.

Материалы и методы. Было проведено поперечное обсервационное исследование с участием 700 человек. Артериальное давление измерялось с помощью стандартного ртутного сфигмоманометра. Физическая активность оценивалась с использованием Глобального вопросника физической активности Всемирной организации здравоохранения. Участники были разделены на группы: малоактивные, умеренно активные и интенсивно активные. Статистический анализ проводился с использованием SPSS версии 16.0.

Результаты. Распространённость нормотонии, предгипертонии и гипертонии составила 65 %, 34,85 % и 0,02 % соответственно. Почти половина участников (46,2 %) были физически неактивны. Предгипертония значительно чаще встречалась среди физически неактивных людей. Повышенный уровень физической активности был связан с более низкими средними значениями систолического и диастолического артериального давления.

Заключение. Физическая неактивность тесно связана с повышенным артериальным давлением. Ранняя модификация образа жизни с акцентом на регулярную физическую активность может предотвратить переход от предгипертонии к гипертензии и снизить будущий сердечно-сосудистый риск.

Ключевые слова: *артериальное давление, физическая активность, предгипертония, Глобальный опросник физической активности (GPAQ), гипертония*

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INTRODUCTION

Blood pressure is a vital physiological parameter that reflects the force exerted by circulating blood on the arterial walls during the cardiac cycle. It is expressed as systolic blood pressure (SBP), representing the peak arterial pressure during ventricular systole, and diastolic blood pressure (DBP), representing the lowest arterial pressure during ventricular diastole. Regulation of blood pressure involves complex interactions between cardiac output, total peripheral resistance, blood volume, arterial compliance, and neurohormonal mechanisms. Persistent elevation of blood pressure beyond physiological limits leads to hypertension, a major modifiable risk factor for cardiovascular, cerebrovascular, and renal diseases [1].

Hypertension is frequently preceded by a transitional phase termed **pre-hypertension** [2], characterized by blood pressure levels above normal but below the diagnostic threshold for hypertension. Individuals with pre-hypertension are at significantly higher risk of progressing to overt hypertension and developing cardiovascular complications [3]. Early detection during this stage is crucial, as lifestyle modification can effectively delay or prevent disease progression.

Prevalence of hypertension and pre-hypertension

Hypertension is one of the most prevalent non-communicable diseases globally. According to the World Health Organization, approximately **1.13 billion people worldwide** suffer from hypertension [4], with nearly two-thirds living in low- and middle-income countries. Globally, raised blood pressure is responsible for an estimated **7.6 million premature deaths annually** [5] primarily due to ischemic heart disease and stroke. The global age-standardized prevalence of hypertension is reported to be approximately 31.9 % in men and 30.1 % in women [6] while pre-hypertension affects nearly **one-third of the adult population**.

In India, the burden of hypertension has increased substantially over the past few decades due to epidemiological transition, urbanization, and lifestyle changes. Community-based studies report that the prevalence of hypertension among Indian adults ranges from **22 to 33 %**, while pre-hypertension affects **30–50 %** of the population [7–9]. The Indian Council of Medical Research (ICMR) and other national surveys have demonstrated a consistent rise in hypertension prevalence across both urban and rural populations, with increasing involvement of younger age groups [10]. Hypertension contributes significantly to cardiovascular morbidity and mortality in India, accounting for nearly **45 % of deaths due to heart disease and 51 % of deaths due to stroke** [11].

At the regional level, studies from Rajasthan have reported a prevalence of hypertension ranging from **18 to 26 %**, with pre-hypertension affecting more than **40–50 %** of adults, particularly in urban and semi-urban settings [12]. These findings indicate a substantial hidden burden of elevated blood pressure and highlight the need for early preventive strategies in institutional and community settings.

Physical activity and blood pressure

Physical inactivity has emerged as one of the most important modifiable risk factors for hypertension. Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure. Regular physical activity plays a critical role in blood pressure regulation by reducing sympathetic nervous system activity, improving endothelial function, enhancing arterial compliance, and decreasing total peripheral resistance [13]. Acute exercise leads to transient increases in systolic blood pressure proportional to cardiac output, whereas chronic physical activity results in sustained reductions in resting blood pressure [14].

Conversely, sedentary behavior is associated with increased sympathetic tone, insulin resistance, obesity, and activation of the renin – angiotensin – aldosterone system, all of which contribute to elevated blood pressure [15]. Epidemiological studies have consistently demonstrated lower prevalence of hypertension and better cardiovascular outcomes among individuals engaging in moderate to vigorous physical activity compared to physically inactive individuals [16].

Young adults, particularly medical students and healthcare workers, represent a vulnerable population due to academic stress, long working hours, sedentary habits, and inadequate physical activity. Despite better health awareness, this group often exhibits a high prevalence of pre-hypertension, which increases long-term cardiovascular risk if left unaddressed [17].

Arterial hypertension represents a major global public health challenge and is a leading cause of cardiovascular morbidity and mortality worldwide. Although the association between elevated blood pressure and sedentary lifestyle is well established, recent evidence emphasizes the need for region-specific and population-specific data to guide preventive strategies. In low- and middle-income countries such as India, rapid urbanization, academic stress, and lifestyle transitions have contributed to increasing physical inactivity, particularly among young adults and healthcare-associated populations. Institutional settings such as medical colleges represent a unique environment where early cardiovascular risk factors may remain undetected despite adequate health awareness. Therefore, examining the graded relationship between physical activity levels and blood pressure categories in this population provides clinically relevant evidence for early screening and targeted lifestyle interventions.

Given the rising prevalence of pre-hypertension and hypertension and the pivotal role of physical activity in blood pressure regulation, it is essential to examine the relationship between physical activity levels and blood pressure in institutional populations. Therefore, the present study was undertaken to assess the prevalence of normotension, pre-hypertension, and hyperten-

sion and to evaluate the correlation between blood pressure and physical activity among adults at RUHS College of Medical Sciences, Jaipur.

MATERIALS AND METHODS

Study design

This study was conducted as a **cross-sectional observational study** to assess the prevalence of normotension, pre-hypertension, and hypertension and to evaluate the association between blood pressure and physical activity among adults.

Study setting

The study was carried out in the **Department of Physiology, RUHS College of Medical Sciences and Associated Hospitals, Jaipur, Rajasthan**, a tertiary care teaching institution catering to a diverse population.

Study duration

The duration of the study was **six months**, including participant recruitment, data collection, and analysis.

Study population

The study population consisted of adults aged **18–60 years**, including:

- Medical and paramedical students;
- Teaching and non-teaching staff;
- Hospital support staff such as guards and laborers.

Study universe and sample size

The study universe comprised approximately **1300 eligible individuals** from RUHS College of Medical Sciences and Associated Hospitals. Among this population, a total of **700 participants** were selected for the study.

The sample size was calculated using prevalence data from previous studies with a **95 % confidence interval and 80 % power**, accounting for a 10 % non-response rate.

Sampling technique

Participants were selected using a **convenience sampling method**, based on availability and willingness to participate during the study period.

Inclusion criteria

- Age between **18 and 60 years**;
- Provided **written informed consent**;
- Apparently healthy individuals, including smokers and alcohol consumers.

Exclusion criteria

- Pregnancy;
- Presence of known cardiovascular diseases such as ischemic heart disease, coronary artery disease, or stroke;
- Presence acute or chronic kidney disease;
- Already diagnosed hypertension, or intake of antihypertensive medications, including diuretics, beta-blockers, angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, calcium channel blockers, or renin inhibitors.

Ethical considerations

Ethical clearance was obtained from the **Institutional Ethics Committee of RUHS College of Medical Sciences** (Approval No. EC/P-62/2021). All participants were informed about the purpose and procedures of the study, and written informed consent was obtained prior to data collection. Confidentiality and anonymity of participants were strictly maintained.

Data collection methods

Socio-demographic and socioeconomic assessment

Data on age, gender, religion, marital status, education, occupation, and residence (urban/rural/semi-urban) were collected using a **pre-tested, self-administered questionnaire**.

Socioeconomic status was assessed using the **Modified Kuppuswamy Socioeconomic Scale (2021)**, which is based on:

- Education of the head of the family;
- Occupation of the head of the family;
- Monthly per capita family income.

Participants were categorized into upper, upper-middle, lower-middle, upper-lower, and lower socioeconomic classes based on the total score.

Anthropometric measurements

Anthropometric measurements were performed according to **National Health and Nutrition Examination Survey (NHANES) guidelines**.

Height

Height was measured to the nearest **0.1 cm** using a standard stadiometer. Participants were asked to stand barefoot with heels, buttocks, and occiput touching the stadiometer.

Weight

Body weight was measured to the nearest 0.1 kg using a calibrated digital weighing scale, with participants wearing light clothing and no footwear.

Body Mass Index (BMI)

BMI was calculated using Quetelet's formula:

$$BMI(\text{kg/m}^2) = \frac{Weight(\text{kg})}{Height(\text{m})^2}$$

BMI was classified according to **WHO adult BMI classification**.

Waist and hip circumference

Waist circumference was measured midway between the lower margin of the last palpable rib and the il-

iac crest at the end of expiration. Hip circumference was measured at the widest part over the greater trochanters.

Waist-to-Hip Ratio (WHR)

WHR was calculated as waist circumference divided by hip circumference. Truncal obesity was defined as WHR > 0.95 in males and > 0.85 in females.

Blood pressure measurement

Blood pressure was measured using a **standard mercury sphygmomanometer** following **American Heart Association guidelines**.

Procedure

- Participants were seated comfortably with back supported and feet flat on the floor.
- A rest period of at least 5 minutes was ensured before measurement.
- Measurements were taken on the left arm, supported at heart level.
- An appropriately sized cuff was applied with the lower edge placed 2–3 cm above the cubital fossa.

Methods

1. ***Palpatory method*:** used to estimate systolic blood pressure.
2. ***Auscultatory method*:** systolic BP was recorded at **Korotkoff Phase I** and diastolic BP at **Phase V**.

Blood pressure was recorded in **three positions**: supine, sitting, and standing. The average of the readings was used for analysis.

Blood pressure was classified according to **Ministry of Health and Family Welfare Guidelines** into normotension, pre-hypertension, and hypertension.

Assessment of physical activity

Physical activity was assessed using the **World Health Organization Global Physical Activity Questionnaire (GPAQ)**.

The questionnaire evaluates physical activity across three domains: activity at work, travel to and from places, and recreational activities.

Physical activity levels were expressed as **Metabolic Equivalent of Task (MET) minutes per week**. Based on GPAQ scoring protocol, participants were categorized into: physically inactive (sedentary); moderately active; vigorously active.

Assessment of stress

Perceived stress was assessed using the **Perceived Stress Scale (PSS-10)** developed by Cohen et al. Scores range – from **0 to 40**. Stress levels were categorized as: mild stress (0–13 points), moderate stress (14–26), and severe stress (27–40).

Statistical analysis

Data were entered into Microsoft Excel and analyzed using **SPSS version 16.0 (Chicago, USA)**. Normality of data was assessed using the **Shapiro – Wilk test.** Continuous variables were expressed as **mean ± standard deviation.** Categorical variables were expressed as **frequency and percentage**. Pearson's correlation coefficient was calculated between continuous variables, namely physical activity expressed as GPAQ-derived MET-minutes per week and systolic and diastolic blood pressure values (mmHg), across the entire study population. Although participants were categorized into physically inactive, moderately active, and vigorously active groups for descriptive analysis, correlation analysis was performed using continuous physical activity scores rather than roup categories to allow valid estimation of linear associations. A ***p*-value < 0.05** was considered statistically significant.

RESULTS

The present observational study conducted in the Department of Physiology, RUHS College of Medical Sciences and Associated Hospitals, Jaipur, included 700 participants aged 18–60 years (mean age – 22.77 ± 6.67 years), comprising 395 males and 305 females. Based on Ministry of Health and Family Welfare criteria, the prevalence of normotension, pre-hypertension, and hypertension was 65 %, 34.71 %, and 0.29 %, respectively.

Anthropometric parameters

Anthropometric measurements including height, weight, body mass index (BMI), waist circumference (WC), hip circumference (HC), and waist/hip ratio (WHR) were recorded for all participants using standard procedures.

TABLE 1

DESCRIPTIVE STATISTICS OF ANTHROPOMETRIC PARAMETERS (*N* = 700)

Parameter	Mean ± SD
Height, cm	168.4 ± 8.7
Weight, kg	63.2 ± 11.4
Body mass index, kg/m^2	22.3 ± 3.9
Waist circumference, cm	87.4 ± 13.3
Hip circumference, cm	94.9 ± 13.6
Waist/hip ratio	0.92 ± 0.002

Physical activity was assessed using the WHO Global Physical Activity Questionnaire (GPAQ), and blood pressure was classified according to the Ministry of Health and Family Welfare guidelines. The association between physical activity levels and blood pressure status is presented below.

TABLE 2
DISTRIBUTION OF PHYSICAL ACTIVITY LEVELS AMONG STUDY PARTICIPANTS (*N* = 700)

Physical activity level	*n*	%
Physically inactive	324	46.2
Moderately active	216	30.85
Vigorously active	160	22.95
Total	700	100

Nearly half of the participants were physically inactive, indicating a high prevalence of sedentary lifestyle in the study population. This is concerning, as physical inactivity at a young age increases the risk of pre-hypertension and future cardiovascular disease. The finding highlights the need for early lifestyle interventions to promote regular physical activity.

TABLE 3
DISTRIBUTION OF BLOOD PRESSURE CATEGORIES (*N* = 700)

Blood pressure category	n	%
Normotensive	455	65
Pre-hypertensive	243	35.71
Hypertensive	2	0.29
Total	700	100

Most participants were normotensive (65 %), reflecting the young and generally healthy study population. However, more than one-third (35.71 %) were pre-hypertensive, indicating a substantial hidden cardiovascular risk. Only a very small proportion (0.29 %) were hypertensive, underscoring the importance of early screening and preventive lifestyle measures.

Pre-hypertension was most prevalent among physically inactive participants (42.3 %) and decreased.

Mean systolic and diastolic blood pressure values demonstrated a clear inverse relationship with physical activity levels, decreasing progressively from inactive to vigorously active participants. Physically inactive individuals recorded the highest mean blood pressure values, indicating greater cardiovascular risk. In contrast, participants engaging in moderate to vigorous physical activity exhibited lower resting blood pressure, reflecting the beneficial effects of regular exercise on vascular tone and autonomic regulation. This trend highlights the protective role of physical activity in maintaining optimal blood pressure levels.

TABLE 6
CORRELATION BETWEEN PHYSICAL ACTIVITY LEVEL AND BLOOD PRESSURE

Variable pair	Correlation coefficient (*r*)	*p*
Physical activity vs. systolic BP	–0.31	< 0.05
Physical activity vs. diastolic BP	–0.28	< 0.05

A statistically significant negative correlation was observed between physical activity levels and both systolic and diastolic blood pressure, indicating that higher physical activity is associated with lower blood pressure.

TABLE 4
ASSOCIATION BETWEEN PHYSICAL ACTIVITY AND BLOOD PRESSURE STATUS

Physical activity level	Normotensive, *n* (%)	Pre-hypertensive, *n* (%)	Hypertensive, *n* (%)	Total
Physically inactive	186 (57.4)	137 (42.3)	1 (0.3)	324
Moderately active	152 (70.4)	64 (29.6)	0 (0.0)	216
Vigorously active	117 (73.1)	42 (26.3)	1 (0.6)	160
Total	455	243	2	700

TABLE 5
MEAN BLOOD PRESSURE VALUES ACCORDING TO PHYSICAL ACTIVITY LEVEL

Physical activity level	Mean systolic blood pressure, mmHg ± SD	Mean diastolic blood pressure, mmHg ± SD
Physically inactive	121.3 ± 7.9	80.2 ± 5.8
Moderately active	117.1 ± 7.2	77.6 ± 5.4
Vigorously active	114.6 ± 6.8	75.9 ± 5.1

DISCUSSION

The present study was conducted to evaluate the relationship between blood pressure and physical activity among adults attending RUHS College of Medical Sciences and Associated Hospitals, Jaipur. The findings of the study highlight a substantial burden of pre-hypertension and a high prevalence of physical inactivity in a predominantly young population, emphasizing the importance of early preventive interventions.

In the present study, 65 % of participants were normotensive, while 34.71 % were pre-hypertensive, and only 0.29 % were hypertensive. The high prevalence of pre-hypertension observed is clinically significant, as pre-hypertension is a well-recognized precursor to established hypertension and future cardiovascular disease. Similar prevalence rates of pre-hypertension among young adults and medical students have been reported in earlier Indian studies, suggesting a rising trend of cardiovascular risk factors at an early age [17–19]. The low prevalence of overt hypertension in the present study can be attributed to the relatively young age group and absence of chronic comorbidities among most participants.

A major finding of this study was the inverse association between physical activity and blood pressure. Mean systolic and diastolic blood pressure values showed a consistent decline with increasing levels of physical activity, with physically inactive participants demonstrating the highest blood pressure values. These findings are in agreement with previous studies that have shown regular physical activity to be effective in reducing resting blood pressure through improved endothelial function, reduced sympathetic nervous system activity, and enhanced arterial compliance [13, 16, 20]. Even moderate levels of physical activity have been shown to reduce systolic blood pressure by 5–7 mmHg, which is associated with a significant reduction in cardiovascular morbidity and mortality at the population level [16].

The present study also revealed that nearly 46.2 % of participants were physically inactive, indicating a high prevalence of sedentary lifestyle. This observation is consistent with other studies conducted among students and institutional populations, where academic stress, prolonged sitting hours, and increased screen time contribute to reduced physical activity levels [21]. Physical inactivity promotes autonomic imbalance, insulin resistance, weight gain, and endothelial dysfunction, all of which play a role in elevating blood pressure.

Anthropometric parameters showed a positive association with blood pressure levels in the present study. Participants with higher body mass index and increased waist/hip ratio exhibited a greater prevalence of pre-hypertension. Obesity contributes to hypertension through multiple mechanisms, including activation of the renin – angiotensin – aldosterone system, increased sympathetic tone, sodium retention, and chronic low-grade inflammation [15]. Similar associations between obesity indices and elevated blood pressure have been reported in previous Indian and international studies [22].

Gender-wise analysis revealed a higher prevalence of pre-hypertension among males compared to females. This finding is consistent with earlier studies and may be attributed to differences in lifestyle habits, stress exposure, and hormonal influences on vascular tone [6].

Although the cross-sectional design of the study limits causal inference, the findings clearly demonstrate the strong association between physical inactivity and elevated blood pressure. The high prevalence of pre-hypertension among young adults indicates a potential future increase in hypertension if timely lifestyle modifications are not implemented.

Overall, the study underscores the need for early screening, regular blood pressure monitoring, and institution-based lifestyle interventions focusing on increased physical activity, weight management, stress reduction, and healthy dietary practices. Promoting physical activity at a young age can play a crucial role in preventing the progression of pre-hypertension to established hypertension and reducing the long-term burden of cardiovascular disease.

CONCLUSION

The present study demonstrates a substantial burden of pre-hypertension among adults at RUHS College of Medical Sciences, Jaipur, with more than one-third of participants exhibiting elevated blood pressure despite their relatively young age. Nearly half of the study population was physically inactive, highlighting the widespread prevalence of sedentary lifestyle practices.

A significant inverse relationship was observed between physical activity and blood pressure, with physically inactive individuals showing higher mean systolic and diastolic blood pressure values. Increased levels of physical activity were associated with lower blood pressure, underscoring the protective role of regular exercise in cardiovascular health. Anthropometric parameters such as higher body mass index and central obesity further contributed to elevated blood pressure levels.

The findings emphasize the importance of early screening, regular blood pressure monitoring, and lifestyle modification, particularly promotion of physical activity, weight management, and stress reduction among young adults. Implementing institution-based preventive strategies can play a crucial role in preventing the progression from pre-hypertension to established hypertension and in reducing the long-term burden of cardiovascular disease.

Limitations

The present study has certain limitations that should be considered while interpreting the findings. First, the cross-sectional design of the study limits the ability to establish a causal relationship between physical activity and blood pressure. Second, physical ac-

tivity was assessed using a self-reported questionnaire, which may be subject to recall bias and over- or under-reporting by participants. Third, the study was conducted in a single tertiary care institution, and the predominance of young adults may limit the generalizability of the results to the wider community. Additionally, blood pressure was measured during a single visit, and long-term variations or white-coat effects could not be assessed. Despite these limitations, the study provides valuable insight into the early burden of pre-hypertension and its association with physical inactivity.

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Conflict of interest

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Authors' contribution

Ankita Tyagi: conceptualization of the study; collection and analysis of the data; creation of the manuscript draft; design and execution of research work, including statistical analysis and interpretation of results.
Sudhanshu Kacker: guidance in study design; critical review of the manuscript and valuable inputs for data interpretation and final editing.
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Information about the authors

Ankita Tyagi – MSc Medicine, Department of Physiology, Rajasthan University of Health Sciences, College of Medical Sciences, 302033, Sector 18, Kumbha Marg, Pratap Nagar, Jaipur, Rajasthan, India. ORCID: https://orcid.org/0009-0002-7133-5003

Sudhanshu Kacker – MD, Department of Physiology, Rajasthan University of Health Sciences, College of Medical Sciences, 302033, Sector 18, Kumbha Marg, Pratap Nagar, Jaipur, Rajasthan, India. ORCID: https://orcid.org/0000-0002-6505-4216

Neha Saboo – MD, Department of Physiology, Rajasthan University of Health Sciences, College of Medical Sciences, 302033, Sector 18, Kumbha Marg, Pratap Nagar, Jaipur, Rajasthan, India. ORCID: https://orcid.org/0000-0002-3874-1459

Munesh Kumar – MD, Department of Gastroenterology, Rajasthan University of Health Sciences, College of Medical Sciences, 302033, Sector 18, Kumbha Marg, Pratap Nagar, Jaipur, Rajasthan, India.

Corresponding author

Ankita Tyagi, ankitatyagi997@gmail.com

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Анкита Тьяги: разработка концепции исследования; сбор и анализ данных; подготовка черновика рукописи; разработка и выполнение исследовательской работы, включая статистический анализ и интерпретацию результатов.
Судханшу Каккер: руководство в разработке дизайна исследования; критический анализ рукописи и ценные замечания по интерпретации данных и окончательному редактированию.
Неха Сабу: руководство в разработке дизайна исследования; критический анализ рукописи и ценные замечания по интерпретации данных и окончательному редактированию.
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Информация об авторах

Анкита Тьяги – магистр медицинских наук, кафедра физиологии, Раджастханский университет медицинских наук, Колледж медицинских наук, 302033, Сектор 18, Кумбха Марг, Пратап Нагар, Джайпур, Раджастхан, Индия. ORCID: https://orcid.org/0009-0002-7133-5003

Судханшу Какер – доктор медицинских наук, факультет физиологии, Раджастханский университет медицинских наук, Колледж медицинских наук, 302033, Сектор 18, Кумбха Марг, Пратап Нагар, Джайпур, Раджастхан, Индия. ORCID: https://orcid.org/0000-0002-6505-4216

Неха Сабу – доктор медицинских наук, кафедра физиологии, Раджастханский университет медицинских наук, Колледж медицинских наук, 302033, Сектор 18, Кумбха Марг, Пратап Нагар, Джайпур, Раджастан, Индия. ORCID: https://orcid.org/0000-0002-3874-1459

Мунеш Кумар – доктор медицинских наук, отделение гастроэнтерологии, Раджастханский университет медицинских наук, Медицинский колледж, 302033, Сектор 18, Кумбха Марг, Пратап Нагар, Джайпур, Раджастхан, Индия.

Для переписки

Ankita Tyagi, ankitatyagi997@gmail.com

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