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Association of Resting Blood Pressure Levels with Pain Sensitivity Parameters among Medical Students

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ABSTRACT

Introduction

Pain perception varies among individuals and is influenced by multiple physiological factors, including blood pressure. The present study aimed to assess the association of resting blood pressure with pain sensitivity parameters among medical students of a medical college.

Methods

This was a cross-sectional study done in first and second year medical students aged 17-25 years. Pain sensitivity was assessed by the Cold Pressor Test. Pearson's correlation analysis was used to determine the association between blood pressure and pain sensitivity parameters. Data were analyzed using SPSS Statistics, with a significance level set at $p<0.05$.

Results

Resting systolic blood pressure increased significantly in both sexes (Males:123.13±5.40 to 126.93±3.97; Females:113.35±8.26 to 119.76±5.67) following cold pressor test, while diastolic BP rose significantly only in females. Males had significantly higher pain threshold (23.32±3.00 vs 20.06 ± 4.15) and pain tolerance (92.18±14.06 vs 65.46±12.81) compared to females, while females reported significantly higher pain ratings (6.57±1.64 vs 5.32±1.08) on the visual analog scale ($p<0.05$). A significant positive correlation was observed between resting blood pressure and both pain threshold and pain tolerance in both males and females. In contrast, pain rating showed a significant negative correlation with both systolic and diastolic blood pressure in males ($r = -0.247$ and -0.343, $p = 0.020$ and 0.001, respectively) and females ($r = -0.320$ and -0.504, $p = 0.004$ and <0.001, respectively).

Conclusion

This study shows an inverse relationship between resting blood pressure and pain sensitivity, with stronger associations observed in females. The study also highlights sex-based differences in both pain perception and physiological response to cold-induced stress.

Keywords

Blood pressure; cold pressor test; medical students; pain sensitivity

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INTRODUCTION

Pain is a sensory and emotional experience that arises in response to actual or possible tissue injury, or is expressed in a way that reflects such damage.[1] Subjective responses to painful stimuli and the use of different measurement methods make it challenging for healthcare provider to assess pain perception and manage pain.[2]

Pain perception is assessed based on an individual's responsiveness to painful stimuli. Pain sensitivity parameters such as pain threshold, pain tolerance, and pain rating help measure how individuals respond to pain.[2] While it is well known that pain can cause a temporary increase in blood pressure, the evidence linking hypertension to reduced responsiveness to acute pain is not as commonly acknowledged.[3] Consequently, under conditions involving sudden pain, a negative relationship between resting blood pressure and pain perception is recognized as a clinical feature referred to as hypertension-associated hypoalgesia.[4]

A systematic review and meta-analysis confirmed that higher blood pressure is significantly related with decreased pain sensitivity, suggesting a complex interplay between cardiovascular regulation and pain processing mechanisms.[5] Experimental laboratory-based pain models have used different types of stimuli—such as mechanical, chemical, electrical, and thermal—to create pain that closely resembles clinical conditions.[6] In this study, the cold pressor test was employed to provoke pain and assess pain sensitivity in healthy young individuals from a medical college in Nepal.

However, most studies examining this association have been conducted in Western populations, with limited research from South Asia, particularly among healthy young adults such as medical students. This represents a notable research gap, as stress, academic pressure, and lifestyle factors may influence both blood pressure and pain perception in this group. The present study aims to explore the association of resting blood pressure and pain sensitivity parameters among medical students of a medical college in Nepal.

METHODS

A cross-sectional study was done to assess the relation of resting blood pressure with pain sensitivity parameters among medical students. The present study was done in the Clinical Physiology Department of Kathmandu Medical College and Teaching Hospital from September 2024 to February 2025. Participants were first and second year MBBS students who volunteered for the study. Ethical clearance was obtained from the Institutional Review Committee of Kathmandu Medical College and Teaching Hospital with Ref number 12072024/10. Medical students aged 17–25 years of age and those wishing to take part and gave informed consent were taken for the study. Individuals with a history of hypertension, chronic pain conditions, or neurological disorder , those taking antihypertensive, analgesic, or psychoactive medications and participants with recent injuries or infections that could alter pain perception were excluded from the study.

Sample size was determined using the following formula: $n=z^2pq/E^2$

where, p = 50% (prevalence taken as 50% for maximum sample size calculation)

q = 1-p = (1-0.50) = 0.50

E = 5 %

At 95 % confidence interval, Z=1. 96

Therefore, n= 384

Since the population size is finite (N = 296), as there are 296 MBBS first and second year students. We used the finite population correction formula: n_finite = n / [1 + (n - 1) / N] where, n = 384, and N = 296.

Substituting the values, for a study with a total population of 296 individuals, the required minimum sample size is 167 to maintain statistical accuracy.

After obtaining informed consent, anthropometric measurements (height, weight, and BMI) were recorded. Their resting blood pressure (BP) was taken in a seated position using mercury sphygmomanometer after a 5-minute rest period. Three readings were taken and the average of the readings was recorded as the final BP measurement. Pain sensitivity was then assessed using the Cold Pressor Test (CPT). Participants were explained about the procedure. Participants placed their non-dominant hand into ice-cold water, up to 5 cm above the wrist. The temperature of water was kept between 4°C and 8°C by adding ice and stirring regularly to keep it uniform.[7] A thermometer was used to check the temperature. Two stopwatches were started when the hand was immersed. As soon as the participant experienced discomfort and expressed "pain" the initial stopwatch was stopped, this moment was noted as the pain threshold. They kept their hand in until the pain became unbearable, then removed it, this was recorded as the pain tolerance using the second stopwatch. Right after the test, blood pressure (on the dominant hand) was recorded. Pain intensity was rated on a visual analog scale from 0 (no pain) to 10 (worst pain possible).[8]

Data was analyzed using SPSS Statistics version 22. Baseline characteristics was expressed in mean±standard deviation. A suitable student's t-test was appropriately applied to determine whether the difference between the average values of the two groups was statistically significant. The association between resting blood pressure and pain sensitivity parameters was assessed using Pearson's correlation analysis. A p-value <0.05 was considered statistically significant.

RESULTS

There were a total of 167 participants in the present study which included 88 males and 79 females. Males had significantly greater height and weight compared to females, Table 1.

The table 2 demonstrates the comparison of systolic and diastolic blood pressure among male and female participants before and after undergoing the cold pressor test (CPT).After the cold pressor test, systolic blood pressure significantly increased in both males and females (p<0.001). Diastolic blood pressure increased significantly in females but not in males (p=0.068).

Males demonstrated considerably greater pain threshold and tolerance than females. Conversely, females reported significantly higher pain ratings (6.57 ± 1.64 vs. 5.32 ± 1.08, p<0.001), indicating a greater subjective perception of pain (Table 3).

In both males and females, resting blood pressure was significantly and positively linked with pain threshold and tolerance. In contrast, pain rating exhibited a significant inverse relationship with both systolic and diastolic resting blood pressure across genders (Table 4).

Table 1. Baseline characteristics of study participants

Parameter	Male (n=88)	Female (n=79)	p-value
Age (years)	20.35±2.15	20.09±2.22	0.44
Height (m)	1.67±0.08	1.55±0.06	<0.001
Weight (kg)	59.90±4.86	51.56±3.84	<0.001
BMI (kg/m^2)	21.57±2.87	21.42±2.36	0.71

DISCUSSION

The present study showed a significant rise in systolic BP following the cold pressor test in both males and females. However, while diastolic BP also showed an upward trend in both genders, the increase was statistically significant only in females. This suggests that the CPT elicited a more pronounced overall BP response in females

Table 2. Comparison of systolic and diastolic blood pressure before and after cold pressor test in males and females

Gender	Blood pressure	Before cold pressure test	After cold pressure test	p-value
Male (n=88)	Systolic	123.13±5.40	126.93±3.97	<0.001
	Diastolic	80.64±7.26	82.11±4.51	0.068
Female (n=79)	Systolic	113.35±8.26	119.76±5.67	<0.001
	Diastolic	73.75±4.89	75.87±4.24	<0.001

Table 3. Gender differences in various pain parameters

Parameter	Male (n=88)	Female (n=79)	p-value
Pain threshold (sec)	23.32±3.00	20.06±4.15	<0.001
Pain tolerance (sec)	92.18±14.06	65.46±12.81	<0.001
Pain rating (0 to 10 in visual analog scale)	5.32±1.08	6.57±1.64	<0.001

Table 4. Correlation between resting blood pressure and pain parameters in males and females

Gender	Resting blood pressure	Pain threshold	Pain tolerance	Pain rating
Male (n=88)	Systolic	r=0.339;p=0.001	r=0.241; p=0.024	r=-0.247p=0.020
	Diastolic	r=0.278; p=0.009	r=0.351; p=0.001	r=-0.343; p=0.001
Female (n=79)	Systolic	r=0.372;p=0.001	r=0.362;p=0.001	r=-0.320; p=0.004
	Diastolic	r=0.526; p<0.001	r=0.378; p=0.001	r=-0.504; p<0.001

compared to males. Our results align with the GenSalt study, which reported that females exhibited a greater maximum systolic BP response to the CPT compared to males.[9] The CPT activates the body's stress response, causing significant narrowing of blood vessels and blood pressure to rise.[10]

Whereas another study by LeBlanc et al. found that males had a higher systolic blood pressure activity to the CPT than females.[11] The reason behind the gender difference in blood pressure activity to the cold pressor test remains uncertain. It has been suggested that sympathetic nervous system activity impacts cardiac output and peripheral resistance, differently in males and females.[12]

Our study revealed significant gender differences in pain parameters assessed during the cold pressor test. Males exhibited a higher pain threshold and pain tolerance in comparison to females, while pain ratings was significantly greater among females than in males. These findings align with previous study conducted by Fillingim et al. who suggested that men generally tolerate pain for a longer duration and have a higher pain threshold than women.[13] Another study done in India showed that women had higher pain sensitivity than men.[14] Whereas other study by Jones et al noted gender differences for pain tolerance but not pain threshold.[15]

The observed differences may be influenced by various factors, including hormonal variations, psychological attributes, and sociocultural norms. Sex hormones are known to influence changes in pain sensitivity and pain relief among both genders. Testosterone has been shown to reduce pain sensitivity. On the other hand, estrogen and progesterone have more complex effects on pain, as they can both increase and decrease pain sensitivity.[16]

However, study by Kumar et al, showed no significant sex-based differences in pain perception, possibly because of variations in pain assessment methods.[17] Another study by Nie H et al. explained that women had lesser pain thresholds than men, possibly because of the limited sample size.[18] One possible explanation is that men may be more driven to endure pain and hide their discomfort due to societal expectations associated with masculinity, while women, influenced by the feminine gender role, may be more likely to express pain and have less motivation to tolerate it.[19] Another review discusses how women often report higher pain levels but receive less pain medication than men, suggesting that gender biases may influence pain management practices.[20]

In this study, both resting systolic and diastolic blood pressures show a significant positive correlation with pain threshold and pain tolerance, while exhibiting a negative correlation with pain rating among both genders. These findings align with the phenomenon known as hypertension-associated hypoalgesia, where elevated blood pressure is related with decreased pain sensitivity. Another study found that in normotensive males, greater resting systolic blood pressure was significantly related with lesser pain ratings during finger pressure pain stimulation, indicating a hypoalgesic effect of elevated blood pressure.[21]One proposed mechanism underlying this relationship involves the activation of baroreceptors due to increased blood pressure. These baroreceptors can stimulate descending pain inhibitory pathways, leading to diminished pain perception.[22]

Additionally, the body reacts to an increase in blood pressure by releasing endogenous opioids, such as endorphins. These naturally occurring opioids might play a role in negative association observed between blood pressure and sensitivity to pain.[23]

A key limitation of this study is the absence of consideration for hormonal levels, which could potentially change the association of blood pressure and pain sensitivity. Additionally, we did not account for the different phases of the menstrual cycle in female participants, which may have influenced the outcomes. Another limitation is the restricted sample, as participants were drawn from a single college, limiting the ability to generalize the results to a wider population. These findings can help in better understanding pain management strategies, especially in clinical settings. It may also encourage further research on using blood pressure as a potential marker to assess pain sensitivity.

CONCLUSION

Young individuals with higher resting blood pressure, particularly females, had exhibited lower pain sensitivity. Additionally, sex differences in both pain perception and cardiovascular responses to stress was seen, with males showing higher pain threshold and tolerance, and females demonstrating greater increases in diastolic pressure and higher pain ratings.

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CONFLICT OF INTEREST

Regarding the research, writing, and/or publication of this work, the author(s) affirm that they have no conflicts of interest.

AUTHOR CONTRIBUTIONS

Gita Khakurel: Research concept, design, literature review, data collection, data analysis, manuscript preparation; Sushil Kharel: Statistical analysis, manuscript preparation; Prabin Kumar Karki: Data collection, manuscript preparation; Kalyan Gautam: Manuscript preparation; Data Collection.

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