

## Cold Pressor Test as a Potential Early Screening Tool for Identifying Young Adults at Risk of Developing Hypertension

Dandi Oka Subantara<sup>1</sup>, Yeli Yulianti<sup>1</sup>

<sup>1</sup>Department of Nursing, Universitas Bhakti Husada Indonesia, Tasikmalaya, Indonesia

Correspondence: **Dandi Oka Subantara**: Jl. Cilolohan No. 36, Tasikmalaya, Jawa Barat, Indonesia; [dandiokasubantara@gmail.com](mailto:dandiokasubantara@gmail.com)

### ABSTRACT

Hypertension remains a major public health concern in Indonesia, with a steadily increasing prevalence across age groups, including young adults. Individuals with a family history of hypertension are at heightened risk due to genetic predisposition and lifestyle factors, making early detection of cardiovascular reactivity essential. The cold pressor test is a well-established physiological stress test used to assess sympathetic activation and acute blood pressure responses. This study aimed to examine the effect of the cold pressor test on systolic and diastolic blood pressure among young adults with a hereditary history of hypertension in Tasikmalaya, West Java. A quasi-experimental quantitative design with a single-group pre-test and post-test structure was employed. The study was conducted over three months at Universitas Bakti Tunas Husada and involved 178 respondents selected through consecutive sampling based on predefined inclusion and exclusion criteria. Blood pressure was measured before and after cold pressor test using a calibrated digital sphygmomanometer, and data were analyzed using descriptive statistics and paired t-tests. The findings demonstrated a significant increase in both systolic and diastolic blood pressure following cold pressor test exposure. Mean systolic pressure rose from 118.80 mmHg to 137.22 mmHg, while mean diastolic pressure increased from 77.70 mmHg to 82.95 mmHg. Both changes were statistically significant ( $p < 0.05$ ), indicating heightened cardiovascular reactivity among individuals with a family history of hypertension. These results suggest that cold pressor test may serve as a useful early screening tool for identifying young adults at risk of developing hypertension, thereby supporting timely preventive interventions.

**Keywords:** hypertension; cold pressor test; blood pressure reactivity; young adults; family history of hypertension

### INTRODUCTION

Hypertension can be assessed through two separate blood pressure measurements taken at five-minute intervals under adequate resting conditions. A systolic blood pressure exceeding 140 mmHg and a diastolic pressure exceeding 90 mmHg are considered indicative of hypertension [1]. Systemic arterial hypertension itself is defined as a persistent, non-physiological elevation of systemic blood pressure, characterized by a resting systolic blood pressure (SBP) of 140 mmHg or higher, a diastolic blood pressure (DBP) of 90 mmHg or higher, or the use of antihypertensive therapy for blood pressure reduction [2]. In Indonesia, the prevalence of hypertension has continued to rise, reaching 34.1% according to the 2018 Basic Health Research (Riskesdas), an increase from 25.8% in 2013. Among younger age groups, the prevalence also increased markedly: in 2013, hypertension affected 8.7% of individuals aged 18–24 years, 14.7% of those aged 25–34 years, and 24.8% of those aged 35–44 years. By 2018, these figures rose to 13.2%, 20.1%, and 31.6%, respectively, demonstrating a significant upward trend across provinces in Indonesia [3].

In 2013, West Java ranked fourth nationally for hypertension prevalence (29.4%), following Bangka Belitung (30.9%), South Kalimantan (30.8%), and East Kalimantan (29.6%). By 2018, West Java had risen to second place among provinces with the highest hypertension burden in Indonesia. Tasikmalaya City, as one of the major urban areas in West Java, reflects this concerning pattern. Data from the Tasikmalaya City Health Office (2021) indicate that hypertension ranks as the most common disease reported in the region [4].

The Cold Pressor Test (CPT), first introduced by Hines and Brown in 1932, is a physiological test designed to evaluate cardiovascular reactivity, particularly acute changes in blood pressure in response to stress. The CPT stimulus combines cold exposure and nociceptive input, triggering thermoregulatory reflexes and global sympathetic activation. This sympathetic surge induces vasoconstriction and an acute rise in systemic arterial pressure, thereby increasing afterload and providing insight into vascular tone and autonomic responsiveness. Blood pressure reactivity measured through CPT is therefore considered an index of vasomotor tone and sympathetic cardiovascular regulation [5].

Among adolescents, several risk factors have been associated with hypertension. Poor sleep quality increases the risk by 4.1 times, elevated BMI-for-age increases the risk by 4.85 times, and a family history of hypertension increases the risk by 3.9 times [6]. Adolescents with hypertensive parents are significantly more likely to develop hypertension compared with those whose parents are normotensive. Singh's study reported that 30–60% of interindividual variation in blood pressure is attributable to genetic factors. Children with two hypertensive parents have a 40–60% likelihood of developing hypertension in adulthood, and the incidence of hypertension in children with hypertensive parents is 4–15 times higher than in those with normotensive parents [7].

Blood pressure classification in adolescents differs from that in adults because blood pressure naturally increases with age. Adolescent hypertension is defined using percentile-based curves, with hypertension diagnosed at 130–139/80–89 mmHg or values exceeding the 95th percentile plus 11 mmHg. Essential hypertension is the most common form in adolescents, typically asymptomatic and often detected only during routine examinations [8]. Unhealthy lifestyle patterns among young adults—including poor dietary habits, reduced physical activity, and excessive consumption of processed foods—contribute not only to hypertension but also to early-onset stroke. Stroke in young adults may also be associated with congenital cardiac abnormalities, and its consequences often require substantial lifestyle and psychological adjustments. Emotional disturbances are frequently observed after stroke and are closely linked to reduced quality of life due to permanent physical disability [9].

The consistently increasing prevalence of hypertension in West Java, particularly in Tasikmalaya City, underscores the urgency of early detection and prevention. Young adults often fail to adopt healthy lifestyle practices, and hypertension commonly progresses without symptoms, making routine screening essential. These concerns form the basis for investigating the influence of the CPT on blood pressure among young adults with a family history of hypertension in Tasikmalaya City. Early identification of heightened blood pressure reactivity may support timely interventions to prevent long-term complications.

This study aims to analyze the influence of the CPT on blood pressure among young adults in Tasikmalaya City who have a family history of hypertension.

## METHODS

This study was conducted over a three-month period at Universitas Bakti Tunas Husada, located in Tasikmalaya City, West Java Province. The institutional setting was selected to ensure controlled environmental conditions for physiological measurement and to facilitate recruitment of young adult participants who met the predetermined eligibility criteria.

The research employed a quantitative approach using a quasi-experimental design. Experimental methods within quantitative research are particularly appropriate when the investigator intends to examine the causal influence of an independent variable—referred to as a treatment or intervention—on a dependent variable under controlled conditions. In this study, the design consisted of a single-group pre-test and post-test structure, enabling the assessment of changes in blood pressure before and after exposure to the CPT. This design was chosen to capture acute physiological responses while maintaining internal validity in the absence of a control group.

The study population comprised young adults or late adolescents with a documented family history of hypertension. Recruitment was conducted by first providing detailed explanations regarding inclusion and exclusion criteria, followed by the selection of participants who met these criteria. A total of 178 individuals were enrolled based on consecutive sampling, a non-probability sampling technique in which all eligible participants who presented during the recruitment period were included until the required sample size was achieved. This sampling strategy was considered appropriate for quasi-experimental research in naturalistic settings.

The independent variable in this study was the CPT, which served as the physiological stressor. The CPT was administered by immersing the participant's hand into cold water at a controlled temperature for a specified duration, following standard CPT protocols. This procedure induces sympathetic activation through cold and nociceptive stimuli, thereby eliciting an acute rise in blood pressure. The dependent variable was the change in blood pressure, measured as the difference between pre-test and post-test systolic and diastolic values. Blood pressure was assessed using a calibrated digital sphygmomanometer, which had been verified by an accredited calibration company recognized by the National Accreditation Committee (*Komite Akreditasi Nasional, KAN*). Measurements were recorded using standardized forms to ensure consistency and traceability. Age and sex were identified as potential confounding variables due to their known influence on cardiovascular reactivity.

Data collection involved the use of structured questionnaires to document demographic characteristics and family history, alongside direct physiological measurements obtained through the sphygmomanometer. The collected data were processed through several stages, including editing, coding, sorting, data entry, and cleaning, to ensure accuracy and completeness prior to analysis. Univariate analysis was conducted to summarize the characteristics of the independent, dependent, and confounding variables. Nominal data were presented as percentages, whereas interval-scale variables were described using mean, median, standard deviation, minimum and maximum values, and 95% confidence intervals. Subsequent inferential analysis employed the Chi-Square test to examine associations and determine the statistical significance of observed differences.

## RESULTS

Table 1 shows that among the 178 respondents with a family history of hypertension, the majority were female, representing 54.5% of the total sample. This indicates that more women than men met the inclusion criteria and participated in the study.

Table 2 demonstrates that the mean age of respondents with a family history of hypertension was 21.66 years with a standard deviation of 1.66 years. The median age was 22 years, and the 95% confidence interval ranged from 21.41 to 21.90 years, indicating a relatively narrow age distribution within the young adult population.

Table 3 indicates that respondents with a family history of hypertension experienced a marked increase in both systolic and diastolic blood pressure following the Cold Pressor Test (CPT). Before CPT, the mean systolic pressure was 118.80 mmHg and the mean diastolic pressure was 77.70 mmHg. After CPT, systolic pressure increased to 137.22 mmHg and diastolic pressure rose to 82.95 mmHg. These findings reflect the expected sympathetic activation triggered by cold-induced stress.

Table 4 shows a substantial increase in systolic blood pressure after the Cold Pressor Test (CPT). The mean systolic pressure before CPT was 118.80 mmHg, rising to 137.22 mmHg afterward. The mean difference of -18.41 mmHg indicates a strong physiological response to the CPT stimulus. The p value < 0.05 confirms that this difference is statistically significant, demonstrating that CPT significantly elevates systolic blood pressure among young adults with a hereditary predisposition to hypertension. The diastolic blood pressure also increased significantly following the Cold Pressor Test (CPT). The mean diastolic pressure before CPT was 77.70 mmHg, increasing to 82.95 mmHg after CPT. The mean difference of -5.24 mmHg indicates a notable rise in diastolic pressure. The p value < 0.05 confirms that this increase is statistically significant, indicating that CPT produces a measurable elevation in diastolic blood pressure among young adults with a family history of hypertension.

Table 1. Distribution of respondent characteristics based on sex

Confounding	Frequency	Percentage
Male	81	45.5
Female	97	54.5

Table 2. Distribution of respondent characteristics based on age

Variable	Mean (SD)	Median	95% CI	p value
Age	21.66 (1.66)	22.00	21.41–21.90	0.000*

Table 3. Mean blood pressure scores before and after the CPT

Variable	Mean (SD)	Median	95% CI	Normality
Blood pressure before intervention (systolic and diastolic)	118.80 (8.97) 77.70 (7.02)	119.00 78.00	0.85;0.90 76;78	0.000 0.029
Blood pressure after intervention (systolic and diastolic)	137.22 (13.66) 82.95 (6.44)	139.00 84.00	135;139 82;83	0.000 0.000

Table 4. Differences in systolic and diastolic blood pressure between before and after the CPT

Variable	Mean (SD) before	Mean (SD) after	df	t	MD (95% CI)	p value
Systolic blood pressure	118.80 (8.97)	137.22 (13.66)	177	-16.10	-18.41 (-20.67; -16.15)	0.000
Diastolic blood pressure	77.70 (7.02)	82.95 (6.44)	177	-9.92	-5.24 (-6.29; -4.20)	0.000

## DISCUSSION

The characteristics of respondents in this study based on sex showed that 97 participants (54.5%) were female and 81 participants (45.5%) were male. This distribution aligns with the findings of Parveen et al., who reported that male respondents constituted 35 individuals (48%) in their sample [10]. Similarly, Xu et al. observed a smaller proportion of male respondents, totaling 38 individuals (44.7%) [11], a pattern also reflected in the study by Dong et al., which reported 134 male respondents (46.6%) [12]. In contrast, Yanti et al. reported a sample composed entirely of female respondents, totaling 80 individuals (100%) [13]. Keller-Ross et al. examined 43 young respondents, consisting of 20 men (46.5%) and 23 women (53.5%), as well as 19 older respondents, including 10 men (52.6%) and 9 women (47.4%). Their findings indicated that older women exhibited a greater initial increase in blood pressure reactivity to the Cold Pressor Test (CPT) compared with older men, whereas younger men and younger women demonstrated significant increases toward the end of the CPT [14].

According to the present researchers, variations across studies regarding the relationship between sex and hypertension risk may be attributed to hormonal and lifestyle factors. Many studies suggest that men have a higher risk of hypertension than women, largely due to the protective effects of estrogen in premenopausal women. However, women experience an increased risk of hypertension after menopause when estrogen levels decline. Additionally, lifestyle factors such as occupational demands and increased time spent outside the home may contribute to elevated hypertension risk among women in certain populations.

Age is a non-modifiable risk factor for hypertension. In this study, respondents ranged from 18 to 25 years old, with a mean age of 21.66 years and a standard deviation of 1.66. Similar age distributions were reported by Parveen et al., who studied adolescents and university students aged 18 to 22 years [10], and by Xu et al., whose sample consisted of young Chinese adults aged 21 to 33 years [11]. The researchers emphasize that early screening for hypertension is essential, as recommended by the national Minimum Service Standards (Standar Pelayanan Minimal, SPM) in the health sector. Early detection is crucial not only for short-term health but also for preventing long-term complications that may impair quality of life. The CPT aligns with these recommendations, as it offers a method for early identification of heightened cardiovascular reactivity among young individuals.

This study demonstrated significant differences in systolic and diastolic blood pressure before and after the CPT. The mean systolic blood pressure increased from 118.80 mmHg before CPT to 137.22 mmHg after CPT, with a mean difference of  $-18.41$  mmHg, indicating a statistically significant elevation among young adults with a family history of hypertension. Similarly, diastolic blood pressure increased from 77.70 mmHg before CPT to 82.95 mmHg after CPT, with a mean difference of  $-5.24$  mmHg, also showing a significant rise following CPT exposure. These findings suggest that individuals with hereditary predisposition exhibit heightened sympathetic reactivity when subjected to cold-induced stress.

Comparable results were reported by Johnson et al., who examined CPT responses among athletes with concussion and healthy controls. Their study found that mean blood pressure increased during CPT at 90 and 120 seconds among concussed athletes, while healthy controls exhibited increases beginning at 30 seconds and peaking at 120 seconds. Systolic blood pressure in concussed athletes increased at 120 seconds, whereas healthy controls showed increases beginning at 60 seconds. Diastolic blood pressure in healthy controls increased from 30 seconds onward, with peak values at 120 seconds. Overall, the study concluded that collegiate athletes with concussion demonstrated blunted and delayed cardiovascular responses to CPT compared with healthy active controls, suggesting impaired sympathetic activation following concussion [15].

Dzakiyya et al. also reported that stress-induced cardiovascular responses to CPT varied among young, healthy individuals. Among 56 respondents, 38 (67.9%) were classified as normoreactors following CPT exposure. This variability may be influenced by metabolic factors and preserved cardiovascular function in younger individuals [16]. According to the present researchers, sympathetic cardiovascular responses are shaped not only by genetic predisposition but also by neurological factors, as the brain modulates the speed and intensity of sympathetic activation. Age also plays a significant role in determining the magnitude of CPT responses.

Young adults must adopt healthy lifestyle behaviors, particularly given that hypertension often presents without noticeable symptoms. Early detection is therefore essential [17]. Non-pharmacological interventions remain accessible, cost-effective, and free of adverse effects; for example, carrot and starfruit juice has been explored as an alternative therapy for hypertension [18]. As hypertension represents an early manifestation of cardiovascular disease in adults, simple and accurate screening methods are urgently needed [19]. Current hypertension management strategies do not adequately consider the age of onset, despite its clinical relevance [20].

This study has several limitations. First, the researchers could not medically verify participants' family history of hypertension, relying instead on self-reported information. Second, no assessment of comorbid conditions or complications was conducted. Third, the study did not differentiate whether the family history of hypertension originated from parents, grandparents, or other relatives, which may influence genetic risk interpretation.

## CONCLUSION

Early adulthood and adolescence are critical periods for detecting early cardiovascular changes, and the CPT plays an important role in this process. CPT provokes a controlled sympathetic response that produces measurable increases in both systolic and diastolic blood pressure, allowing clinicians and researchers to identify individuals who may be at elevated risk. Young adults who exhibit an exaggerated blood pressure rise during CPT—classified as hyperreactors—are more likely to develop hypertension later in life, making CPT a valuable early screening tool for this population.

## Ethical consideration, competing interest and source of funding

-This study received ethical approval from the Ethics Committee of the Faculty of Nursing, Universitas Indonesia. All procedures adhered to established ethical principles, including respect for human dignity, protection of participant privacy and confidentiality, equitable treatment, and careful consideration of potential risks and benefits. Participants were informed of the study objectives, procedures, and their rights, and written informed consent was obtained prior to participation.

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