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Comparative effect of tomato juice, walking, and their combination on blood pressure in prehypertension

Efek perbandingan konsumsi jus tomat, jalan kaki, dan kombinasinya terhadap tekanan darah pada individu dengan prehipertensi

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Abstract

This study examined the individual and combined effects of tomato juice and increased daily walking on blood pressure in prehypertensive adults. A total of 34 sedentary participants aged 19–36 years were randomly assigned to four groups: control, tomato juice, walking, and a combination of both. The intervention lasted for 14 days, during which participants consumed 200 ml of unsalted tomato juice and/or increased their steps by a minimum of 5,000 steps per day (on average), tracked using health (iOS) or Google Fit (Android). Blood pressure was measured before and after the intervention and analyzed using paired t-tests ($p<0,05$). All intervention groups showed a reduction in systolic blood pressure, with the combination group showing the most significant decrease—from 128,75±4,20 to 110,50±6,05 mmHg ($p=0,000$) for systolic and from 82,50±8,40 to 74,74±3,92 mmHg ($p=0,033$) for diastolic pressure. A significant correlation between body mass index and blood pressure reduction was also observed, suggesting that body weight may influence the effectiveness of these lifestyle interventions.

Keywords: prehypertension, tomato juice, walking intervention, blood pressure, non-pharmacological therapy

Abstrak

Penelitian ini meneliti efektivitas konsumsi jus tomat, peningkatan langkah harian, dan kombinasi keduanya terhadap tekanan darah pada individu dengan prehipertensi. Sebanyak 34 partisipan dengan gaya hidup sedentari berusia 19–36 tahun dibagi secara acak ke dalam empat kelompok: kontrol, jus tomat, langkah harian, dan kombinasi. Intervensi dilakukan selama 14 hari, dengan partisipan mengonsumsi 200 ml jus dan/atau meningkatkan langkah sebanyak minimum 5.000 langkah per hari, yang diukur dengan menggunakan aplikasi Health (iOS) atau Google Fit (Android). Pengukuran tekanan darah dilakukan sebelum dan sesudah intervensi dan dianalisis dengan uji t berpasangan ($p<0,05$). Seluruh kelompok intervensi menunjukkan penurunan tekanan darah sistolik, dengan kelompok kombinasi memberikan hasil paling signifikan dari 128,75±4,20 menjadi 110,50±6,05 mmHg ($p=0,000$) untuk sistolik, dan dari 82,50±8,40 menjadi 74,74±3,92 mmHg ($p=0,033$) untuk diastolik. Korelasi signifikansi juga ditemukan pada variabel indeks massa tubuh dan penurunan tekanan darah, yang menunjukkan bahwa berat badan dapat memengaruhi efektivitas intervensi gaya hidup.

Kata Kunci: prehipertensi, jus tomat, jumlah langkah harian, tekanan darah, terapi non farmakologis

Introduction

Hypertension is a major health problem that requires global attention, particularly because of its high prevalence and significant impact on public health. According to the World Health Organization (2021), approximately 1,28 billion adults globally have hypertension, with two-thirds living in low-income and middle-income countries. Predictions show that the number of

people with hypertension will continue to increase, with estimates reaching 1,56 billion adults by 2025. This phenomenon occurs because hypertension is often referred as a "silent killer," where its early symptoms are rarely noticed, resulting in many individuals being unaware that they have hypertension until the condition becomes severe.

According to the Indonesia Basic Health Survey (Riskesdas) data from 2018, the prevalence of hypertension among individuals over 18 years of age was 34,11%, a significant increase from the 2013 prevalence of 25,8%. The most recent 2023 survey showed a slight decline of 30,8% (Kemenkes, 2023), possibly due to increased health awareness, early screening programs, or lifestyle shifts during the post-pandemic period. However, there is an urgent need to prevent the development of hypertension. The prevalence of prehypertension remains high, and evidence shows that approximately 26,1% of prehypertensive individuals eventually develop full hypertension (Ishikawa et al., 2017). This proves that early identification and management of prehypertension is important to reduce long-term cardiovascular risk.

Non-pharmacological approaches, such as consuming tomato juice, can be used to lower blood pressure in individuals with prehypertension. Tomatoes contain lycopene and potassium, which play a role in vasodilation and help reduce blood pressure (Septimar et al., 2020). In addition, lycopene, an antioxidant, can inhibit oxidation in the endothelium, indirectly reducing the risk of hypertension. Lycopene, along with other carotenoids, also plays an important role in maintaining cardiovascular health (Wolak et al., 2019).

The link between prehypertension and cardiovascular diseases emphasizes the importance of a comprehensive approach, including lifestyle changes such as increasing physical activity. Previous studies have shown that individuals who are physically active have a lower cardiovascular risk compared to those who are inactive (Lestari et al., 2020). Physical activity lowers blood pressure by improving vascular elasticity and stabilizing heart function (Arija et al., 2018).

Murcia-Lesmes et al. (2024) showed that tomato juice consumption affected the reduction in both diastolic and systolic pressures in hypertensive patients. Wolak et al. (2019) also supported the benefits of lycopene from tomatoes in reducing blood pressure in patients with hypertension. Yuenyongchaiwat et al. (2018) found that increasing daily steps to 10,000 steps per day effectively lowered the blood pressure in patients with hypertension.

However, randomized controlled trials (RCTs) that combine tomato juice consumption with increased daily steps in prehypertensive sedentary individuals remain limited. Therefore, this study aimed to explore the impact of combining tomato juice consumption with increased daily steps to reduce blood pressure in sedentary individuals with prehypertension.

As the prevalence of hypertension has increased and effective interventions to curb prehypertension development remain limited, this study is important. The findings from this study are expected to contribute significantly to further understanding of non-pharmacological approaches in the prevention and management of hypertension as well as open opportunities for the development of practical, low-cost, and more effective preventive methods for broader public health applications in the future.

Methods

This study was a randomized controlled trial with four intervention groups. Blood pressure measurements and daily steps were performed five times: during the screening phase (days 7 and 0), intervention monitoring (days 7 and 14), and post-intervention (day 21). Participants were stratified by sex during randomization to ensure equal male and female distribution to allow for potential gender-based analysis, which was conducted from January 2024 to March 2024 at the Srengseng Community Health Center, West Jakarta.

Data were collected from sedentary individuals with prehypertension, with 34 participants equally divided by sex into four groups. The inclusion criteria were adults aged 19–36 years with an average number of steps per week of less than 5,000 steps, prehypertension, no concurrent medical interventions, and willingness to follow study protocols. Participants who disliked tomatoes or used high-antioxidant supplements were excluded from the study. The minimum sample size was calculated based on the effect size estimation for comparing the two groups, with 95% confidence and 80% power, resulting in 32 subjects.

Tomato juice was prepared by mixing 1,500 g of red tomatoes with 500 ml of water, blending for 3 min, and straining to produce 10 servings. Each participant consumed 200 ml of juice daily during lunch for 14 d. The step count was increased by 5,000 steps per day and tracked using Health for iOS and Google Fit for Android.

Data were collected at five time points: (1) 7 days before the intervention, (2) immediately before the intervention, (3) 7 days after the start of the intervention, (4) 14 days after the start of the intervention, and (5) 7 days post-intervention. The data included identity, pulse rate, blood pressure (systolic and diastolic), and average daily steps.

Statistical analysis was performed using descriptive statistics for body mass index (BMI)) and paired t-tests for pre- and post-intervention blood pressure, as the primary aim was to assess changes over time within each intervention group. A significance level of $p<0,05$ was applied, and statistical analyses were performed using SPSS 25.0, while Microsoft Excel 2019 was used for data organization and visualization. Although previous studies have explored the effects of tomato juice and walking separately, few have evaluated their combined impact on prehypertensive adults. This study aimed to fill this gap by assessing and comparing the effectiveness of tomato juice, walking, and their combination in reducing blood pressure.

This study received ethical approval from the Faculty of Dental Medicine, Universitas Airlangga (No. 0048/HRECC.FODM/I/2024). All participants provided written informed consent before participation. Data confidentiality was ensured and all personal information was strictly used for research purposes.

Result and Discussion

This study included 34 subjects who were divided into four intervention groups: control (10), tomato juice (8), increased daily steps (8), and a combination of tomato juice and increased daily steps (8). The characteristics of the subjects included age, sex, and Body Mass Index (BMI) status, which are important for understanding the distribution of subjects and their potential impact on the study outcomes.

Table 1. Subject characteristics

Characteristics	Intervention Types							
	Control		Tomato Juice		Daily Steps		Juice and Steps	
	n	%	n	%	n	%	n	%
Age (years)								
19 - 24	1	12,5	0	0	1	12,5	0	0
25 - 30	3	37,5	1	12,5	2	25	2	25
31 - 36	4	50	7	87,5	5	62,5	6	75
Gender								
Male	4	50	4	50	4	50	4	50
Female	4	50	4	50	4	50	4	50
BMI Status								
Normal	2	25	1	12,5	4	50	2	25
Overweight	4	50	5	62,5	2	25	4	50
Obesity type 1	2	25	2	25	2	25	1	12,5
Obesity type 2	0	0	0	0	0	0	1	12,5
Obesity type 3	0	0	0	0	0	0	0	0
BP Status H-0								
Normal	0	0	0	0	0	0	0	0
Prehypertension	10	100	8	100	8	100	8	100
BP Status H-21								
Normal	0	0	6	75	6	75	8	100
Prehypertension	10	100	2	25	2	25	0	0

BMI = Body mass index; BP = Blood pressure

Table 2. Blood pressure and pulse rate changes

Parameter		Intervention Types				p-value
		Control	Tomato Juice	Daily Steps	Juice and Steps	
Blood Pressure (S)*	Pre	133,88±4,49	131,13±5,28	129,13±3,98	128,75±4,20	0,000
	Post	131,25±6,11	118,61±3,70	117,63±5,01	110,50±6,05	
p-value		0,214	0,000	0,000	0,000	
Blood Pressure (D)*	Pre	81,13±7,70	78,88±3,40	74,88±6,33	82,50±8,40	0,000
	Post	81,88±6,33	74,25±6,32	74,63±6,05	74,74±3,92	
p-value		0,891	0,090	0,939	0,033	
Pulse Rate**	Pre	81,00±9,97	82,25±6,21	86,13±8,77	84,63±7,43	0,863
	Post	82,25±8,19	82,25±4,71	86,00±8,40	84,25±9,71	
p-value		0,736	1,000	0,977	0,932	

*Data in mmHg units; **beats per minute (bpm).
S = Sistolic; D = Diastolic

The majority of subjects in all groups fell within the 31-36 age range in terms of age, as shown in Table 1, with the highest proportion found in the tomato juice group (87,5%) and the combination of juice and daily steps group (75%). The control and daily step groups also had a significant percentage of patients in this age range (50% and 62,5%, respectively). In contrast, subjects in the 19-24 age range were rare, appearing only in the control group (12,5%) and the daily steps group (12,5%). The 25-30 age range was more evenly distributed, with the tomato juice group having the lowest percentage of participants (12,5%). While this age distribution was slightly skewed toward older participants, the general balance across groups helped reduce the likelihood of age acting as a confounding factor in blood pressure outcomes. However, no formal interaction analysis has been conducted to evaluate the moderating effect of age.

The sex distribution showed a consistent balance across all groups. Each group consisted of 50% male and 50% female participants, indicating no sex bias in the selection of study participants.

BMI status showed a more significant variation among the subjects. In the control group, the majority (50%) were overweight and the remaining 25% were classified as obesity type 1. A similar pattern was observed in the tomato juice group, in which 62,5% of the subjects were overweight and 25% had obesity type 1. Meanwhile, the daily steps group had a higher proportion of individuals with normal BMI (50%). Although such variation may influence responsiveness to the intervention, no subgroup or interaction analyses were performed. Therefore, any interpretation related to BMI remains observational and cannot be considered conclusive.

Table 2 shows statistically significant reductions in both systolic and diastolic blood pressure across all intervention groups. The combination group achieved the greatest reduction in systolic pressure (mean change of 18,25 mmHg), which may be considered clinically meaningful in a prehypertensive population. Although paired t-tests were used to evaluate the pre-post changes within each group, no formal between-group comparisons were conducted. Therefore, the conclusions regarding the superiority of one intervention over another should be interpreted with caution.

These data show that the majority of the subjects, especially in the tomato juice, combination juice, and step groups, were overweight or obese. This is important because BMI status may affect responses to interventions, particularly in relation to blood pressure and physical activity. Subjects who are overweight or obese may be more susceptible to changes in blood pressure caused by diet and physical activity modifications, as expected from the tomato juice and increased daily step interventions in this study. This statement is supported by the study by Andersen et al. (2021), which highlights that physical activity and dietary modifications, such as increased daily steps and healthy food consumption, significantly improve blood pressure control, especially in individuals with elevated BMI. While this suggests that such individuals may respond more markedly to interventions aimed at reducing blood pressure due to their higher baseline risk, no formal subgroup or interaction

analysis was conducted in this study. Therefore, this interpretation should be considered observational rather than conclusive

Post-intervention data showed a higher proportion of blood pressure normalization in the intervention groups than in the control group, with the combination group showing the greatest improvement. These findings are consistent with those of prior research, as Whelton et al. (2018) stated that lifestyle interventions, such as diet and increasing physical activity, significantly reduced blood pressure in patients with hypertension. Similarly, a study by Gay et al. (2016) also emphasized that lifestyle modifications, combining both physical activity and a diet rich in fruits and vegetables and low in sodium, can effectively normalize blood pressure in individuals with prehypertension. According to Odai et al. (2019), the daily consumption of tomato juice resulted in a significant reduction in both systolic and diastolic blood pressure among hypertensive patients. While our results align with these patterns, the present study's shorter duration (14 days), lack of confounder control, and absence of between-group statistical comparisons indicate that conclusions regarding causality or comparative effectiveness should be interpreted with caution.

Based on Table 2, the study results showed significant changes in systolic and diastolic blood pressure following the intervention, particularly in the group receiving tomato juice and increased daily steps. These findings align with previous studies that demonstrated that consuming 200 ml of tomato juice daily can lower blood pressure in individuals with prehypertension and hypertension (Odai et al., 2019). The tomato juice group showed a reduction from 131,13 ± 5,28 to 118,61 ± 3,70 mmHg (p = 0,000), reflecting strong within-group improvement.

A reduction in blood pressure was also observed in the group with increased daily steps, where systolic blood pressure decreased from 129,13±3,98 to 117,63±5,01, with a p-value of 0,000, demonstrating a significant effect of increased physical activity on sedentary individuals. This is consistent with a study conducted by Ali et al. (2022), who reported that sedentary individuals who increased their physical activity over 14 days showed a significant reduction in blood pressure.

The group that received the combination of tomato juice and daily steps experienced the most significant decrease in systolic blood pressure, from 128,75±4,20 to 110,50±6,05, with a p-value of 0,000. This reduction indicates that the combined intervention was more effective than a single intervention. Additionally, diastolic blood pressure in this group also showed a significant decrease, from 82,50±8,40 to 74,74±3,92, with a p-value of 0,033, suggesting that the combination of tomato juice and increased daily steps can effectively lower diastolic blood pressure. Talarowski et al. (2019) conducted a systematic review of the impact of diet and physical activity on hypertension management, emphasizing the combined effects of weight loss, healthy eating, and physical activity on normalizing blood pressure in hypertensive individuals. This reduction suggests a potential additive benefit of combining dietary and physical activity interventions, although no between-group statistical tests were performed.

On the other hand, the control group, which did not receive any intervention, showed an insignificant decrease in systolic blood pressure, from 133,88±4,49 to 131,25±6,11, with a p-value of 0.214. Diastolic blood pressure in this group did not show any significant changes (p = 0,891). These results are in line with the research by Thomopoulos et al. (2021), which states that the systolic blood pressure from the control group showed a slight decrease, but this was not statistically significant (p >0,05), reflecting minimal or no effect compared to the active intervention groups.

There were no significant changes in pulse rate based on the intervention type or pre- and post-intervention. The p-values were consistently high (p value >0,05), ranging from 0,736 to 1,000, indicating that none of the intervention types or intervention periods had a significant effect on pulse rate. This finding is supported by a study conducted by Mejía-Mejía et al. (2021), which stated that reductions in blood pressure (BP) do not necessarily lead to significant changes in pulse rate (PR). A study by Garg et al. (2023) found that while both systolic and diastolic BP decreased significantly after interventions, such as deep breathing, changes in pulse rate were minimal and statistically insignificant.

Table 3. Blood pressure changes based on gender

Blood Pressure		Gender		p-value
		Male	Female	
Systolic	Pre (H-0)	131,31±5,06	130,13±4,53	0,489
	Post (H-21)	119,44±10,48	119,56±7,87	0,970
Diastolic	Pre (H-0)	79,63±7,33	79,06±7,13	0,827
	Post (H-21)	76,25±5,40	76,50±7,35	0,913

Table 3 shows that both male and female subjects experienced reductions in systolic and diastolic blood pressure after the intervention. The systolic blood pressure (H-0) for males was 131,31±5,06 and decreased to 119,44±10,48 on H-21, while for females, the initial systolic blood pressure (H-0) was 130,13±4,53 and decreased to 119,56±7,87 on H-21. This reduction in systolic blood pressure was consistent in both sexes but did not show a statistically significant difference, with a p-value of 0,489 for males and 0.970 for females. These results are consistent with the study by Seguret and Steichen (2021), which found that there were no significant differences in hypertension prevalence between sexes, indicating that both males and females responded similarly to lifestyle interventions aimed at blood pressure control. Similarly, Bager et al. (2023) also stated that sex differences in blood pressure management were minimal, highlighting that both men and women showed comparable outcomes when following similar treatment protocols for hypertension.

The initial diastolic blood pressure for males (H-0) was 79,63±7,33 and decreased to 76,25±5,40 on H-21, while for females, it was 79,06±7,13, decreasing to 76,50±7,35. Despite this reduction, the difference in diastolic blood pressure was not statistically significant, with p-values of 0,827 for males and 0,913 for females.

These results indicate that while the intervention successfully lowered blood pressure in both males and females, there was no significant difference in the response between the sexes. The similar reduction in blood pressure across both sexes suggests that other factors, such as age, obesity, and health conditions (e.g., diabetes), which could influence prehypertension prevalence, as highlighted in the study by Kibria et al. (2018), may not have had a significant impact in this study's context.

Tabel 4. Blood pressure changes based on Body Mass Index (BMI) status

Blood Pressure	BMI Status				
		Normal	Overweight	Obesity I	Obesity II
Systolic	Pre	130,11±4,08	130,2±5,56	131,71±3,73	137,00
	Post	120,00±8,73	117,47±9,67	123,43±8,98	118,00
	p-value	0,0016	0,0000	0,0343	-
Diastolic	Pre	77,11±7,94	80,13±6,83	79,14±6,64	89,00
	Post	73,89±5,37	77,80±5,56	76,61±9,09	75,00
	p-value	0,0637	0,3098	0,3559	-

Note: Paired t-tests were used to assess differences within each BMI category. "-" indicates no statistical test was performed due to limited sample size (n = 1).

Based on Table 4, which examines changes in blood pressure by Body Mass Index (BMI) status, the results show that both systolic and diastolic blood pressure decreased across all BMI categories, including normal, overweight, obesity type I, and obesity type II.

In subjects with normal BMI, the initial (pre-intervention) systolic blood pressure was 130,11±4,08 mmHg, which decreased to 120,00±8,73 mmHg after the intervention (post-intervention). A similar reduction was observed in diastolic blood pressure, which decreased from 77,11±7,94 mmHg to 73,89±5,37 mmHg after the intervention. Subjects who were overweight showed a systolic blood pressure decrease from 130,2±5,56 mmHg to 117,47±9,67 mmHg, while diastolic blood pressure dropped from 80,13±6,83 mmHg to 77,80±5,56 mmHg.

For subjects with obesity type I, systolic blood pressure also decreased from 131,71±3,73 mmHg to 123,43±8,98 mmHg, while diastolic

blood pressure decreased from 79,14±6,64 mmHg to 76,61±9,09 mmHg. A significant reduction was also observed in subjects with obesity type II, where systolic blood pressure decreased from 137,00 mmHg to 118,00 mmHg, and diastolic blood pressure dropped from 89,00 mmHg to 75,00 mmHg.

This study indicates that overweight and obese subjects experience a greater reduction in blood pressure than those with a normal BMI. Within-group analysis showed statistically significant systolic blood pressure reductions in the overweight ($p = 0,000$) and obesity I ($p = 0,034$) categories, while reductions in the normal BMI group were notable ($p = 0,002$). This finding supports the study by Hu et al. (2017), who stated that the prevalence of prehypertension and hypertension increased as BMI increased. Angelantonio et al. (2016) stated that individuals with higher BMI often face elevated risks of hypertension, which can lead to increased morbidity and mortality rates. Nishioka et al. (2020) explained that excess body fat contributes to hypertension through several mechanisms, including inflammatory cytokine release from adipose tissue that leads to endothelial dysfunction and increased vascular resistance; heightened sympathetic nervous system activity that increases heart rate and vascular tone; insulin resistance, which promotes sodium retention and further stimulates the sympathetic nervous system (both contribute to increased blood pressure); and structural changes in blood vessels, such as hypertrophy and increased stiffness, which hinder their ability to expand. Maintaining body composition through appropriate lifestyle changes can mitigate these effects and improve blood pressure control.

This study also suggests that individuals with a higher BMI tend to have higher blood pressure, and a reduction in weight or BMI can contribute to more significant blood pressure reductions. Sadeghi-Gandomani et al. (2021) also noted that a reduction in BMI can positively influence the reduction in blood pressure, as shown in this data, where subjects with overweight and obesity statuses exhibited significant decreases in blood pressure following the intervention.

Conclusion

This study demonstrated that all three interventions, tomato juice interventions, increased daily steps, and a combination of both, are effective in reducing blood pressure in individuals with prehypertension. However, combination intervention was the most effective, highlighting the added benefit of integrating dietary and physical activity strategies. These findings support the comparative aim of this study and suggest that a combined approach may offer greater cardiovascular protection than either intervention alone. The study also found a correlation between Body Mass Index (BMI) and blood pressure, where subjects with overweight BMI tended to have higher initial blood pressure than those with normal BMI, although no significant differences in blood pressure reduction were observed between the sexes.

The combination of tomato juice and increased daily steps was the most recommended intervention for lowering blood pressure in prehypertensive individuals, as it resulted in the most significant post-intervention blood pressure reduction. These findings also highlight the importance of managing BMI as part of a more comprehensive strategy for blood pressure reduction. Integrating moderate daily walking with dietary sources of lycopene, such as tomato juice, provides a practical, low-cost strategy for early blood pressure management. This approach should be incorporated into lifestyle counseling or public health initiatives aimed at preventing hypertension in young adults.

Similar studies should be conducted over longer periods to evaluate the long-term effects of these interventions. Additionally, future research could expand by considering other factors, such as overall dietary patterns and the influence of genetic factors on blood pressure, providing broader insights into the prevention of prehypertension.

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