

ผลการใช้น้ำมะนาวกับการออกกำลังกายแบบสมาธิบำบัด SKT ต่อระดับความดันโลหิตในผู้ป่วยความดันโลหิตสูง

The Effect of Using Lime Juice and SKT Exercise on Blood Pressure among Patients with Hypertension

รัตนา บุญพา พัชรี ไจการุณ*

Rattana Boonpha Patcharee Jaigarun*

วิทยาลัยพยาบาลบรมราชชนนีสรรพสิทธิประสงค์ คณะพยาบาลศาสตร์ สถาบันพระบรมราชชนก อุบลราชธานี 34000
College of Nursing, Sanpasithiprasong, Faculty of Nursing, Praboromarajchanok Institute, Thailand 34000

บทคัดย่อ

โรคความดันโลหิตสูงเป็นโรคไม่ติดต่อเรื้อรังและปัจจัยเสี่ยงสำคัญของโรคหัวใจและหลอดเลือด แม้การรักษาด้วยยาเป็นแนวทางหลัก แต่การดูแลแบบไม่ใช้ยาที่สอดคล้องวัฒนธรรมมีบทบาทสำคัญในการควบคุมความดันโลหิต การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาผลของการดื่มน้ำมะนาวร่วมกับการออกกำลังกายแบบสมาธิบำบัด SKT ต่อการควบคุมความดันโลหิตในผู้ป่วยที่มีความดันโลหิตสูง การวิจัยกึ่งทดลองแบบวัดซ้ำในกลุ่มเดียว กลุ่มตัวอย่างคือผู้ป่วยความดันโลหิตสูงจำนวน 48 คน ดื่มน้ำมะนาวผสมน้ำก่อนอาหารเช้า และออกกำลังกายแบบสมาธิบำบัด SKT ท่าที่ 1 และ 2 ทุกเช้า ต่อเนื่อง 4 สัปดาห์ ความดันโลหิตถูกวัดก่อนทดลองและทุกสัปดาห์ วิเคราะห์ข้อมูลด้วยสถิติเชิงพรรณนาและการวิเคราะห์ความแปรปรวนแบบวัดซ้ำ ผลการวิจัยพบค่าความดันโลหิตซิสโตลิกลดจาก 145.8 ± 9.5 มม.ปรอท เหลือ 129.7 ± 18.2 มม.ปรอท และค่าไดแอสโตลิกลดจาก 91.0 ± 6.2 มม.ปรอท เหลือ 74.1 ± 13.5 มม.ปรอท ($F = 262.25$, $p < 0.01$; $F = 26.78$, $p < 0.01$) และพบความแตกต่างอย่างมีนัยสำคัญของช่วงเวลาด้วยการทดสอบ Bonferroni สรุปได้ว่าการดื่มน้ำมะนาวร่วมกับการออกกำลังกายแบบสมาธิบำบัด SKT ช่วยควบคุมระดับความดันโลหิตและสามารถประยุกต์ใช้ในการส่งเสริมสุขภาพระดับชุมชนได้

คำสำคัญ: ความดันโลหิตสูง, ระดับความดันโลหิต, น้ำมะนาว, การออกกำลังกายแบบสมาธิบำบัด SKT

Abstract

Hypertension is a major noncommunicable chronic disease and an important risk factor for cardiovascular diseases. Although pharmacological treatment is the primary approach, culturally appropriate nonpharmacological care plays a crucial role in blood pressure control. This study aimed to examine the effects of lime juice consumption combined with Somporn Kantharadussadee Triumchaisri (SKT) meditative exercise on blood pressure control among patients with hypertension. A quasi-experimental one-group repeated-measures design was employed. The participants consisted of 48 patients with hypertension who consumed diluted lime juice before breakfast and practiced SKT meditative exercise (postures 1 and 2) every morning for four consecutive weeks. Blood pressure was measured at baseline and weekly throughout the intervention period. Data were analyzed using descriptive statistics and repeated-measures analysis of variance.

*Corresponding Author: *Email: patcharee_jai@bcnsp.ac.th

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The results showed that systolic blood pressure significantly decreased from 145.8 ± 9.5 mmHg to 129.7 ± 18.2 mmHg, while diastolic blood pressure decreased from 91.0 ± 6.2 mmHg to 74.1 ± 13.5 mmHg ($F = 262.25$, $p < .01$; $F = 26.78$, $p < .01$). Significant differences across time points were confirmed using Bonferroni post hoc tests. In conclusion, lime juice consumption combined with SKT meditative exercise effectively improved blood pressure control and may be applied as a community-based health promotion intervention.

Keywords: Hypertension, Blood Pressure, Lime Juice, SKT Exercise

Introduction

Hypertension remains a critical global health concern, affecting over a billion adults and resulting in millions of deaths annually. The World Health Organization (WHO) Global Report reveals that only about 54% of adults with hypertension are diagnosed, and a mere 21% manage to control it effectively.¹ In Thailand, the 2019–2020 National Health Examination Survey identified an age-standardized prevalence of 25.7% among adults², while provincial data from Ubon Ratchathani in fiscal year 2025 indicated that 81.54% of individuals suspected of hypertension received confirmatory diagnostic follow-up, and 18.94% of those screened with severe blood pressure levels (SBP ≥ 180 mmHg and/or DBP ≥ 110 mmHg) were diagnosed with hypertension.³ Among those diagnosed, only 51.5% were aware of their condition, 47.9% received treatment, and just 22.7% achieved control, highlighting the ongoing challenges in managing hypertension in the country and the urgent need for scalable, non-pharmacological interventions.

Lifestyle changes are vital for managing hypertension. Numerous studies have shown that regular physical activity, stress management, and dietary improvements can significantly lower both systolic and diastolic blood pressure.^{4,5} Citrus fruits, particularly lemons and limes, are rich in flavonoids, potassium, vitamin C, and other bioactive compounds that enhance endothelial function, promote vasodilation, and reduce oxidative stress.

Experimental studies suggest that citric acid and lemon juice can lower blood pressure and induce vasorelaxation in spontaneously hypertensive rats.⁶ In humans, a randomized clinical trial combining garlic and lemon juice showed a significant reduction in blood pressure among hyperlipidemic adults,⁷ while smaller studies using lemon juice alone reported immediate but short-lived effects.⁸ Beyond nutrition, mind–body exercises are recognized as effective complementary approaches. Meta-analyses of randomized controlled trials have confirmed that practices such as Tai Chi and qigong can substantially reduce blood pressure among middle-aged and older adults.^{4,5} Similarly, Thai traditional exercises like Rusie Dutton have been associated with improved blood pressure and overall well-being.⁹ The Somporn Kantharadussadee Triumchaisri (SKT) exercise—a rhythmic, meditative Thai movement—has also shown promising outcomes, with SKT meditation training linked to reduced blood pressure in individuals experiencing hypertensive urgency.¹⁰

Existing evidence indicates that citrus-based diets and mind–body exercises independently contribute to blood pressure reduction, yet the research remains fragmented. Most citrus studies emphasize lemons and short durations, while mind–body exercise trials differ in context and design. In Thailand, SKT has strong cultural roots and potential for hypertension control, but prior studies have been limited to hospital settings. Importantly,

combining lime juice intake with SKT meditative exercise may generate a synergistic antihypertensive effect, as citrus-derived flavonoids and vitamin C enhance endothelial nitric oxide bioavailability and vascular function, while SKT meditation promotes parasympathetic activation, reduces sympathetic overactivity, and attenuates stress-related neuroendocrine responses. The integration of vascular and autonomic pathways may therefore facilitate more sustained blood pressure regulation than either intervention alone.^{11,12} To date, no published research has investigated the combined effects of lime juice consumption and SKT exercise for sustained blood pressure regulation. Given their affordability, cultural relevance, and feasibility in community settings, this study aims to examine whether daily lime juice intake combined with SKT exercise can significantly lower blood pressure among hypertensive patients in a rural Thai community, providing evidence for an integrative and culturally grounded lifestyle intervention.

Objectives

To evaluate how the combination of lime juice and SKT exercise influences blood pressure in patients with hypertension, starting from the baseline and continuing through four weekly evaluations. It was hypothesized that daily lime juice intake combined with SKT exercise would result in a statistically significant reduction in both systolic and diastolic blood pressure.

Methodology

Study Design and setting: The study employed a quasi-experimental design characterized by a one-group repeated measures strategy. This type of design suits community studies lacking randomization or controls.¹⁰ The study took place in a subdistrict health-promoting hospital in the Muang Sam Sip district of Ubon Ratchathani province, Thailand, integrating community-based primary care.

Participants: This study included 48 patients with physician-diagnosed hypertension. Participants were eligible if they were aged 20 years or older, of either sex, and had received continuous care at a health-promoting hospital for at least one year. Those with severe comorbidities (e.g., heart or renal failure), contraindications to exercise, or citrus allergies were excluded. To reduce selection bias, participants were randomly selected from the hypertension registry. Sample size was estimated using G*Power 3.1 (effect size = 0.235⁷, α = 0.05, power = 0.95), indicating a minimum of 42 participants; an additional 10% was included for potential attrition, yielding a total of 48. This approach is consistent with established research practices.¹⁴

Intervention: The intervention combined daily lime juice intake with SKT exercise. Participants consumed 15 ml of freshly squeezed lime juice diluted in 150 ml of water, taken 30 minutes before breakfast, as validated by five experts. Lime juice, rich in potassium, vitamin C, and flavonoids, has been reported to improve endothelial function, reduce vascular resistance, and decrease oxidative stress.^{15,16} Previous studies also suggest that citrus juices can lower both systolic and diastolic blood pressure.¹⁷ In addition, participants performed SKT types 1 and 2 each morning (20 repetitions each). SKT emphasizes breathing and mindfulness, supporting autonomic balance and stress reduction.¹⁸ Participants received initial guidance followed by home practice with weekly follow-up. This approach aligns with holistic hypertension management.^{19,20}

Instruments: Data were collected using a structured form that recorded demographic characteristics and weekly blood pressure measurements. Participants were asked to rest in a seated position for at least five minutes before measurement, following standard guidelines. During each visit, two readings were taken at one-minute intervals, and the average was used for analysis.²¹⁻²³

Blood pressure was measured using validated automated digital sphygmomanometers (Omron). All devices were regularly calibrated and certified by the Medical Sciences Center, Department of Medical Sciences, Ministry of Public Health, Ubon Ratchathani Province, Thailand, to ensure accuracy and consistency throughout the study.

Ethical Approval Statement: This study received approval from the Subcommittee on Human Research Ethics at Boromarajonani College of Nursing, Sanpasithiprasong (No. 18/2564, January 21, 2021). Prior to participation, all participants received detailed information about the study objectives, procedures, potential risks and benefits, available health service support, and their right to withdraw at any time without consequences; written informed consent was obtained. Data were analyzed and reported in aggregated form only. All data were password-protected, accessible solely to the research team, and will be securely destroyed three years after study completion.

Data Collection Procedure: Village Health Volunteers (VHVs) were pivotal in the recruitment process, as they were responsible for identifying eligible participants, securing their consent, and

ensuring compliance with the study protocols. The involvement of VHVs in community-based research in Thailand has been shown to significantly boost participant engagement and adherence.²⁴ Before the intervention began, participants underwent training and demonstration sessions to ensure they could properly prepare lime juice and execute SKT exercises. Data collection was conducted at the start (week 0) and then weekly for four weeks, all under standardized conditions by trained research assistants.

Data Analysis: Data were analyzed using Jamovi version 2.7. Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize participant characteristics. Changes in systolic and diastolic blood pressure across five time points (baseline and weeks 1–4) were examined using repeated measures ANOVA ($df = 4, 188$). The sphericity assumption was assessed using Mauchly's test and was not violated ($p > 0.05$), allowing interpretation based on the sphericity-assumed model. When significant differences over time were observed, Bonferroni-adjusted post hoc tests were conducted to compare pairwise differences. Statistical significance was set at $p < 0.05$.^{25,26}

Results

Table 1 Baseline characteristics of participants (n = 48)

Characteristics	n (%)	Mean $\pm$ SD
Sex		
Male	17 (35.4)	–
Female	31 (64.6)	–
Age (years)	–	61.0 $\pm$ 8.4
< 59 years	21 (43.8)	–
$\geq$ 59 years	27 (56.2)	–
Alcohol consumption		
Non-drinker	47 (97.9)	–
Drinker	1 (2.1)	–
Body Mass Index (kg/m ²)	–	25.7 $\pm$ 3.6
Normal (18.5–22.9)	15 (31.3)	–
Overweight (23.0–29.9)	18 (37.5)	–
Obese ($\geq$ 30.0)	15 (31.3)	–

From Table 1, The study involved 48 hypertensive patients, predominantly women (64.6%) with a mean age of 61 years (SD $\pm$ 8.4). Most participants were non-drinkers (97.9%), and 37.5%

were overweight. Overall, the sample reflected typical rural Thai hypertensive characteristics—older, female, and with generally healthy lifestyles.

Table 2 Changes in systolic and diastolic blood pressure across four weeks of intervention (n = 48)

Time point	Baseloine	Week1	Week2	Week3	Week4
SBP (mmHg) Mean $\pm$ SD	145.8 $\pm$ 9.5	136.7 $\pm$ 16.9	135.3 $\pm$ 15.7	133.2 $\pm$ 17.6	129.7 $\pm$ 18.2
DBP (mmHg) Mean $\pm$ SD	91.0 $\pm$ 6.2	81.8 $\pm$ 9.7	81.0 $\pm$ 12.4	79.2 $\pm$ 11.3	74.1 $\pm$ 13.5

SBP=Systolic Blood Pressure; DBP=Diastolic Blood Pressure

From Table 2, at baseline, Initially, the mean SBP was recorded at 145.8 $\pm$ 9.5 mmHg, while the mean DBP was 91.0 $\pm$ 6.2 mmHg. Over the course of the four-week intervention, both SBP and DBP

consistently decreased, culminating in values of 129.7 $\pm$ 18.2 mmHg for SBP and 74.1 $\pm$ 13.5 mmHg for DBP by the end of the fourth week.

Table 3 Repeated measures ANOVA and post-hoc results for blood pressure (n = 48)

Outcome	F statistic	p value	Post-hoc (Bonferroni) findings
Systolic BP	262.25	<0.01	Baseline > Weeks 1–4 (all p <0.01) greatest reduction at Week 4 (–16.1 mmHg)
Diastolic BP	26.78	<0.01	Baseline > Weeks 1–4 (all p <0.01) greatest reduction at Week 4 (–16.9 mmHg)

From Table 3, the repeated-measures ANOVA revealed significant temporal effects for both SBP (F = 262.25, p < 0.01) and DBP (F = 26.78, p < 0.01). Bonferroni post-hoc tests verified that the initial readings were significantly higher than those in all subsequent weeks (p < 0.01). The most substantial reductions were noted in the final week, with SBP decreasing by 16.1 mmHg and DBP by 16.9 mmHg, highlighting the intervention’s potent impact on blood pressure control.

Discussion

The main goal of this research was to assess the impact of daily lime juice intake combined with SKT exercise on the blood pressure of individuals with hypertension living in a rural area of Thailand. Throughout the four-week intervention, there were

significant reductions in both systolic and diastolic blood pressure, with the most notable improvements occurring in the fourth week. These results align with the study’s objectives and suggest that interventions tailored to cultural practices, which incorporate local dietary habits and traditional exercises, can be highly effective in managing blood pressure.

The observed reductions in blood pressure (around 16 mmHg systolic and 17 mmHg diastolic) were greater than those typically reported for single-component interventions. Previous quasi-experimental studies of SKT reported reductions of 2–10 mmHg, depending on intervention duration and participant characteristics.^{27–29} The greater effect in this study may reflect the combined influence of lime juice and SKT. SKT likely enhances parasympathetic activity, contributing to blood

pressure reduction. It may also act through autonomic pathways involving baroreceptor signaling and regulation of arginine vasopressin, which plays a role in maintaining vascular tone and hemodynamic stability.^{27,28,31}

Similarly, dietary interventions with citrus flavonoids or orange juice enriched with hesperidin have led to modest yet significant improvements of 3–5 mmHg in adults with mild hypertension.^{30,33} The more substantial effects noted in this study suggest a potential synergistic benefit from combining lime juice, which is rich in bioactive flavonoids, potassium, and vitamin C,³⁴ with SKT, a mind-body practice that promotes relaxation and activates the parasympathetic nervous system.³¹

At the physiological level, vitamin C and organic acids from lime juice enhance endothelial nitric oxide bioavailability and vascular function, while SKT meditation promotes autonomic balance by increasing parasympathetic activity and reducing sympathetic drive, together synergistically improving baroreflex sensitivity and blood pressure regulation. Although some high-quality studies have reported modest or inconsistent blood pressure effects when citrus supplementation or mindfulness-based interventions are applied independently, the integration of vascular and autonomic mechanisms may explain the greater antihypertensive effects observed in this study.^{30,35}

These findings are consistent with the expanding evidence base that supports non-pharmacological and culturally relevant strategies for hypertension management. In Thailand, community-focused programs have effectively employed nurse-led teams and Village Health Volunteers to decrease salt consumption and enhance hypertension control in rural communities. The integration of lime juice and SKT into these initiatives could be both practical and sustainable,

given the widespread availability of limes in local markets and the cultural significance of SKT as a Thai practice. This method directly addresses the challenges in managing hypertension in rural areas, where economic and accessibility issues can limit adherence to long-term medication regimens.

The processes responsible for these effects align with existing research. Citrus bioactives have been demonstrated to facilitate vasodilation through nitric oxide and alleviate oxidative stress,^{5,6,7,8,10} while meditative practices improve autonomic control and lower stress-induced sympathetic activity.^{32,33,33}

The progressive decline noted in this study indicates that the consistent engagement in SKT, coupled with daily lime juice intake, leads to cumulative improvements in vascular and autonomic functions.

Recommendation and conclusion

Combining lime juice and SKT offers a low-cost, culturally appropriate approach for community care. Caution is needed for certain conditions, and adherence should be monitored. Future studies should use randomized designs with larger samples and longer follow-up to confirm effectiveness and safety.

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