Original Article

เกณฑ์การรับรู้และความชอบของรสชาติเกลือ: ผู้ที่มีความดันโลหิตสูงเทียบกับผู้ที่มีสุขภาพดี

Recognition threshold and preference of salt taste: hypertensive versus healthy individuals

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บทคัดย่อ การศึกษานี้ดำเนินการเพื่อวัดเกณฑ์รสชาติเค็มและประเมินระดับความชอบรสเค็มระหว่างคนไทยที่มีความดันโลหิตสูงและมีสุขภาพดี ใช้สารละลายโซเดียมคลอไรด์ที่มีความเข้มข้นต่างกันโดยมีเปอร์เซ็นต์โซเดียมคลอไรด์บรรจุอยู่ในน้ำกลั่นเท่ากับ 0% 0.25% 0.5% 0.75% 1% และ 2% เพื่อตรวจวัดเกณฑ์รสชาติเกลือของผู้เข้าร่วม 48 คน โดยแบ่งออกเป็น กลุ่มควบคุม (25) และกลุ่มความดันโลหิตสูง (23) ผู้เข้าร่วมทุกคนที่มีอายุตั้งแต่ 30 ถึง 50 ปี โดยกลุ่มเดิมไม่มีประวัติความดันโลหิตสูง ผู้ทดลองทุกคนผ่านการทดสอบโดยระบุรสชาติเค็มได้ (โดยใช้โซเดียมคลอไรด์ความเข้มข้นต่างกัน) และให้คะแนนความชอบรสเค็ม (โดยมีความเข้มข้น 1% และ 2% ของโซเดียมคลอไรด์) เกณฑ์การรับรสเค็มระหว่างผู้ที่มีความดันโลหิตสูงและผู้ที่มีสุขภาพแข็งแรงไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p > 0.05$) ในทางตรงกันข้าม ความชอบรสเค็มมีความแตกต่างกันอย่างมีนัยสำคัญ โดยผู้เข้าร่วมที่มีสุขภาพดีจะชอบรสเค็มมากกว่า ($p < 0.05$)

การประยุกต์ใช้ในทางปฏิบัติ: ภาวะความดันโลหิตสูงไม่เปลี่ยนแปลงหรือทำให้การรับรู้รสเค็มลดลง นอกจากนี้ ผู้ที่เป็นโรคความดันโลหิตสูงยังมีตัวบ่งชี้ที่ดีในการปฏิเสธรสเค็ม ซึ่งอาจเป็นปัจจัยบวกในการจำกัดการบริโภคเกลือ เนื่องจากปริมาณที่มากเกินไปอาจทำให้เกิดความดันโลหิตสูงได้

คำสำคัญ: ความดันโลหิตสูง โซเดียมคลอไรด์ รสชาติ การรับรู้รส เกณฑ์การรับรส

Abstact This study was conducted to measure salty taste threshold and evaluate the degree of preference of salty taste between hypertensive and healthy Thai people. Different concentrations of sodium chloride solution with percentages of sodium chloride they contained as distilled water (0%), 0.25%, 0.5%, 0.75%, 1%, and 2% were used to detect salt taste threshold among 48 participants that were divided into the control group (25) and hypertension group (23).

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All participants aged from 30 to 50 years with the former group having no history of hypertension. Every subject underwent a test where they recognized the salty taste (using different concentrations of sodium chloride) and rated their liking of the salty taste (with concentrations of 1% and 2% of sodium chloride). Salty taste thresholds between hypertensive and healthy people were not significantly different ($p > 0.05$). In contrast, salty taste preference was significantly different, with the healthy participants having a higher preference for the taste ($p < 0.05$).

Practical application: having hypertension does not alter or impair salty taste perception. Moreover, hypertensive participants showed a good indicator of rejecting salty taste, which may be a positive factor in limiting their salt intake, as the excess amounts may lead to a high blood pressure.

Keywords: hypertension, sodium chloride, taste, taste perception, taste threshold.

INTRODUCTION

Hypertension is considered a major contributing factor to stroke, cardiovascular diseases, and kidney disease. It was documented that 970 million people are affected, and 9 million people are killed by hypertension each year (Chockalingam et al. 2006). High blood pressure is called the "silent killer" since it often has no warning signs or symptoms (Kalehoff and Oparil 2020; Rapport 1999). In Thailand, it is considered one of the major causes of cardiovascular diseases. According to the statistics, 25 percent of the Thai population is reported to be suffering from hypertension which is about 13 million people but only 44 percent are aware of their condition (Reddy et al. 2015; Tiptaradol and Aekplakorn 2012).

Sodium is considered an important nutrient for the body. It is required in a very small amount; 500 mg to 1500 mg of sodium per day is considered optimal (Cook et al. 2020). It helps in the regulation of the fluid balance in the body, but excess salt consumption can pose a threat to the kidneys as it becomes difficult to excrete (Mente et al. 2021). In the majority of people, excess sodium is excreted through urine and sweat, however in some situations, due to certain genetic characteristics, the excess sodium is not excreted and is retained in the body, which was estimated to occur in 20% of the population (Liu et al. 2014). The retention of sodium leads to an increase in the extracellular volume, thus leading to higher cardiac output with high tissue perfusion. Due to the continued high pressure, the ventricular chambers become narrower and thicker which forces the heart to work harder leading to enlarged heart muscle. The force increases with each contraction and higher pressure damages the heart vessels raising the blood pressure (Aslanger et al. 2016).

Sodium chloride has been utilized in various scientific investigations related to blood pressure. The relationship between salt intake and blood pressure was first suggested by Ambard and Beaujard in 1904 (Ha 2014). Later, it has been reported that a diet with higher-than-normal salt intake (15 grams/day) leads to hypertension. In addition, when this amount was reduced, it took around six months for blood pressure to get back to normal (Liu et al. 2014). This indicates that consuming salt in larger amounts is a risk factor for hypertension and it may pose a higher risk to participants who already have high blood pressure. On the other hand, it has been demonstrated that a low-salt diet was beneficial in treating hypertension (Ha 2014; He and MacGregor 2002; Kempner 1948). Nevertheless, it is still inconclusive whether participants with hypertension have a lower preference for salty taste, which may contribute to further helping these participants adhere to the doctor's recommendation and reduce their overall intake. Therefore, the purpose of this study was to measure salt taste threshold and compare the preference for salty taste between hypertensive and healthy Thai participants.

MATERIALS AND METHODS

This study was approved by the Committee in the Ethics of Research in Human Being of Dentistry and Pharmacy Mahidol University Institutional Review Board with Protocol No. MU-DT/PY-IRB 2016/046.1909. The procedure was explained to all participants and written consent was obtained from each participant prior to the experiment.

Sodium chloride solution preparation

Food-grade salt and distilled water were used to prepare the test solutions. A sodium chloride solution of 1M was prepared with 58.4 grams of salt. Six solutions used for the experiment were diluted from the 1M Sodium chloride solution. The solutions diluted were graded by percentages of sodium chloride they contained as distilled water (0%), 0.25%, 0.5%, 0.75%, 1%, and 2%. The solution was prepared in advance and stored in bottles at room temperature at the Oral Biology Laboratory.

Enrolled sample

The participants for this study were healthy and hypertensive individuals between the ages of 30 to 50. Initially, the control and the hypertensive group had 30 participants each. Participants were selected according to the inclusion and exclusion criteria shown in Table 1.

Sample size calculation

The sample size of 30 participants were calculated based on the study of the previous clinical studies (85.7%). Although the minimum required sample size for a 95% confidence interval (the level of significance for all statistical tests) was 25 participants, a sample size of 25 participants were enrolled. However, this study should use only 25 participants both groups. Note that the experiment was not successful in 2 participants from the study group, therefore, they were excluded. So, the study group had only 23 participants.

Table 2. showed the steps involved in the experiment. Participants who met these criteria were subsequently approached to participate in the research. The participants were informed about the procedure of the experiment and the test solution, and a consent form was obtained (Nikam 2015).

Subjects were asked to refrain from smoking, consuming alcohol, and eating or drinking anything except water for one hour before the experiment and were told to brush their teeth with water only. A questionnaire was provided to record the medication history of the participants such as the medications consumed, time, and frequency of consumption.

Salt recognition threshold and level of preference

Participants were blinded to the content and the strength of the solutions. They were asked to specify when and what tastes they recognize, as well as their feeling for each concentration (Nikam 2015). Participants were given 20 ml of the test solution in a plastic cup starting from the lowest concentration to the highest concentration. Each solution was rinsed for 5 seconds and between each concentration the mouth was rinsed with plain water to prevent any carry-on effect (Nikam 2015). The solution at which the participant correctly identified the taste was the recognition threshold. To confirm, the participants were given the preceding lower concentration. Subsequent lowering of the concentrations was done until no taste was perceived by the participant, but termination of taste sensitivity was done if no taste was perceived, and the concentration was assumed to be correctly identified. The concentration at which the taste solution was correctly identified by the participant two times in a row and failed to identify the taste solution at the preceding lower concentration was labeled as the recognition threshold (Nilsson 1979). Moreover, participants were asked to mark the location where they feel the taste such as the lateral side of the tongue or the palate. Using a Vertical 5-Point labeled scale, each person marked his/her feeling for the concentration, being extremely strong, strong, neutral, weak, and extremely weak. Labeled Affective Magnitude (LAM) test was used to assess the participant's preference for the solution at 1% and 2% solution, also using a Vertical 5-Point labeled scale to record the result, being extremely like (5), like (4), neutral (3), dislike (2) and extremely dislike (1) (Simmen et al. 2004).

Table 1 The selection of participants.

Inclusion Criteria	Exclusion Criteria:
○ Healthy Participants aged 30-50	○ Smokers
○ Participants aged 30-50 with a medical history of hypertension.	○ Addiction to alcohol
	○ Oral Lesion
	○ Illnesses that could alter taste:
	○ Diabetes Mellitus
	○ Facial Nerve Palsy

Table 2 The steps of the procedure for the experiment

1. Taste solutions given in increasing concentrations from the lowest to highest. The mouth was rinsed between each solution.
2. The participants correctly identified the taste.
3.The same concentration was reapplied.
4. Explained the procedure to the participants.
5. Participants rinsed their mouths with water.
6. Correctly identified the taste twice.
7. This concentration was the recognition threshold.

Statistical Analysis

For this study, the data collected were analyzed using the program SPSS (PASW version 18). To compare the means of the two groups, Independent Samples Mann-Whitney U Test was used. A *p*-value of less than 0.05 indicated statistical significance between the test and the control groups.

RESULTS

From Table 3, it could be seen that there was no significant difference in the taste recognition threshold between the hypertension and non-hypertension groups. Fig. 1 was right skewed for both the groups. The median threshold for both groups was 2 (*p*-value= 0.16).

Regarding the LAM, and as seen in Fig. 2. The median for LAM1% is 2.5 for hypertension and 4 for the non-hypertension group. There was a significant difference between the 2 groups (*p*-value= 0.04). In other words, salty taste preference was significantly less in the hypertensive group. Data on 5 participants were lost (3 study, 2 control). Thus, the results are based on 45 participants.

From Fig. 3, it could be noticed that for the taste threshold in the control group, the tongue was the main area where taste was perceived (62.5%). From further breakdown in Fig. 4, it was seen that the middle of the tongue had the highest percentage of recognition with 34.8%. The other areas had an equal percentage of taste perception.

As for the taste threshold hypertension group, the tongue was again the main area where taste was perceived (69.4%) (Fig. 5). From further breakdown in figure 6, it was seen that the middle of the tongue had the highest percentage of recognition with 44.0%. The other areas varied and had larger differences between each other as compared to the control. (Fig. 6).

DISCUSSION

As mentioned earlier, it is well-documented that higher-than-normal salt intake has a negative consequence on an individual's overall health, represented mainly by elevated blood pressure and what it could result in at a later stage, such as cardiovascular diseases and stroke (Ha 2014). Moreover, this could be a bigger problem if participants diagnosed with hypertension still consume relatively high amounts of salt. On the other hand, it would be beneficial if these participants lose their preference for salt following a certain period of time, during which salt intake is reduced, as suggested by their medical consultant. Thus, this study was carried out, in order to investigate whether participants who had high blood pressure were still sensitive to salty tastes as same as healthy individuals and if the overall taste of salt was still preferred for those participants, as opposed to normal people.

Table 3 Summary of the median threshold and the median LAM 1%

Group of participants	n	Threshold Median (Min, Max)	n	LAM 1% Median (Min, Max)
Hypertension group	23	2 (2,6)	22	2.5 (1,5)
Non-hypertension group	25	2 (2,5)	23	4 (1,5)
P-value		0.16		0.04*

n: number, LAM: Labeled Affective Magnitude

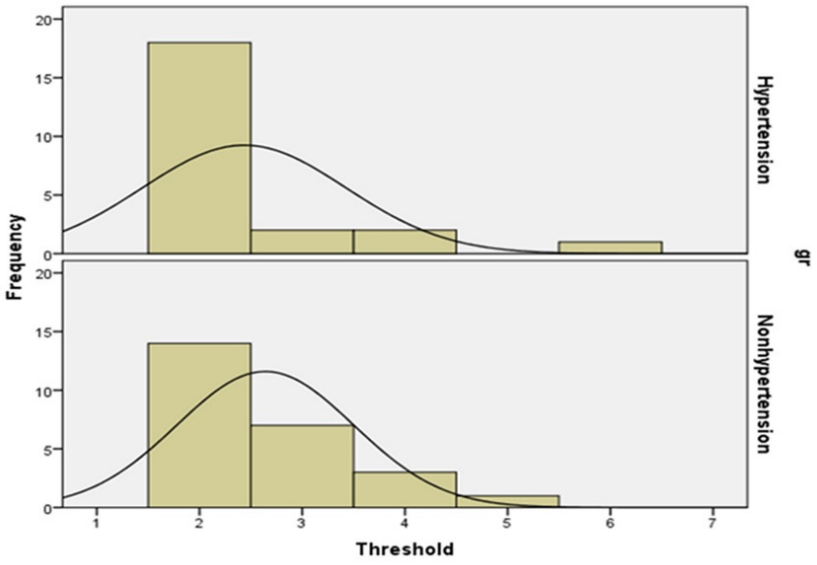

Fig. 1 recognition threshold between hypertension and non-hypertension groups

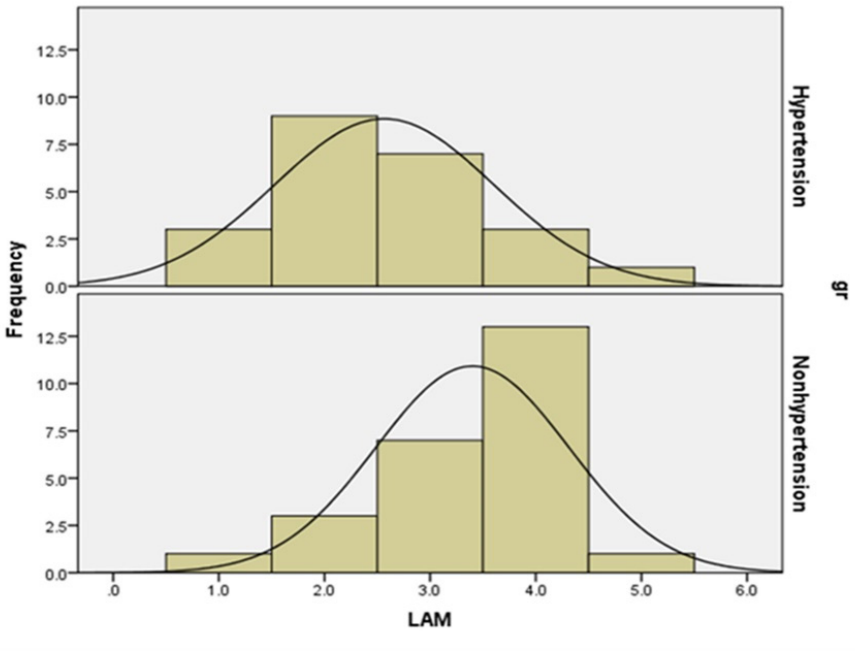

Fig. 2 Labeled Affective Magnitude (LAM) between hypertension and non-hypertension groups.

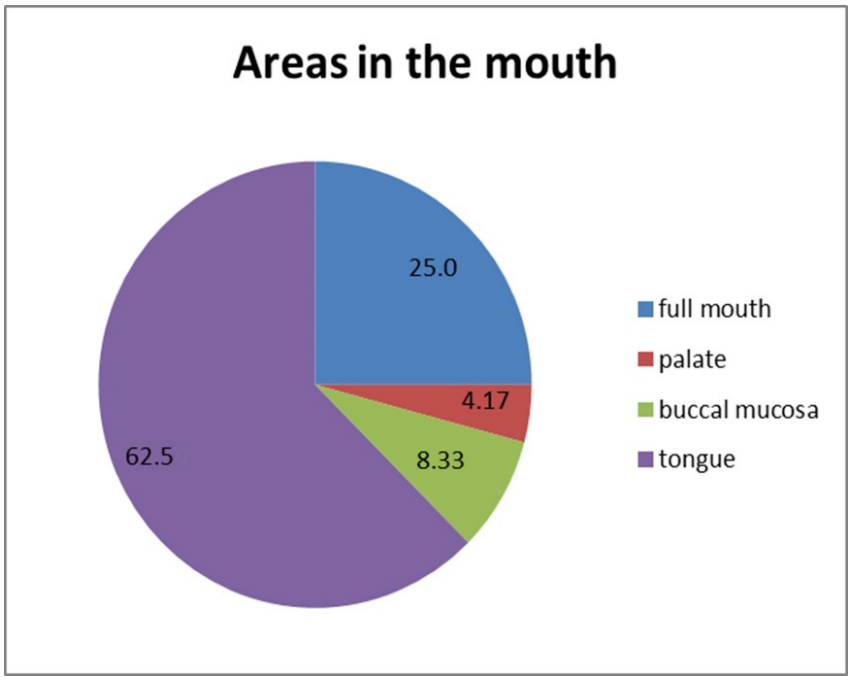

Fig. 3 breakdown of areas in the mouth where salt taste was perceived in the control group.

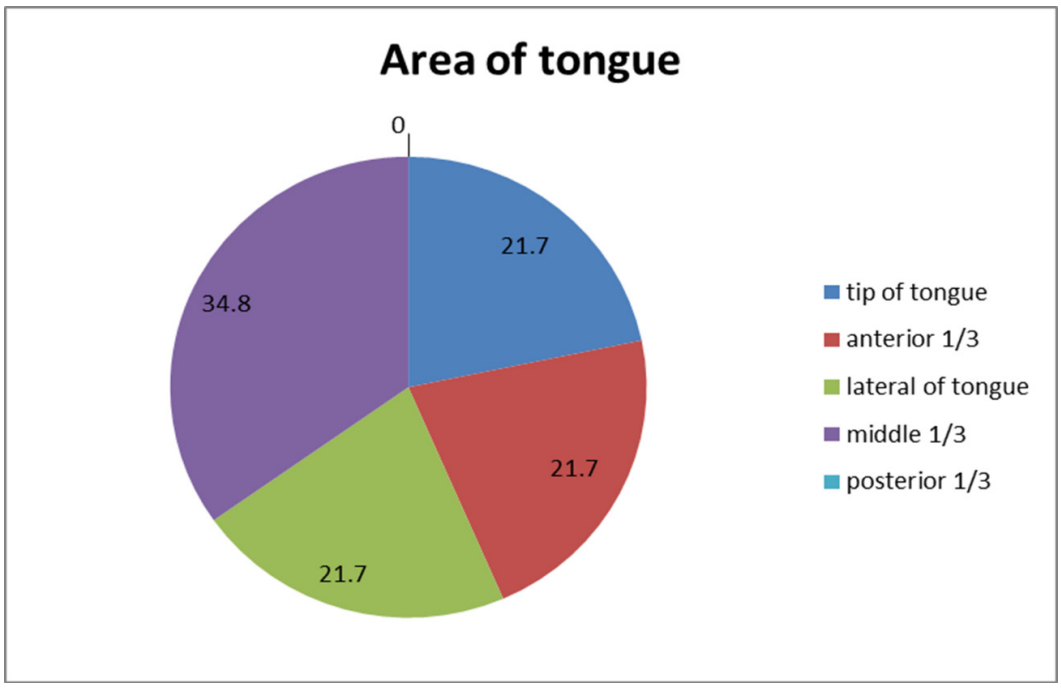

Fig. 4 breakdown of areas of the tongue where salt taste was perceived in the control group.

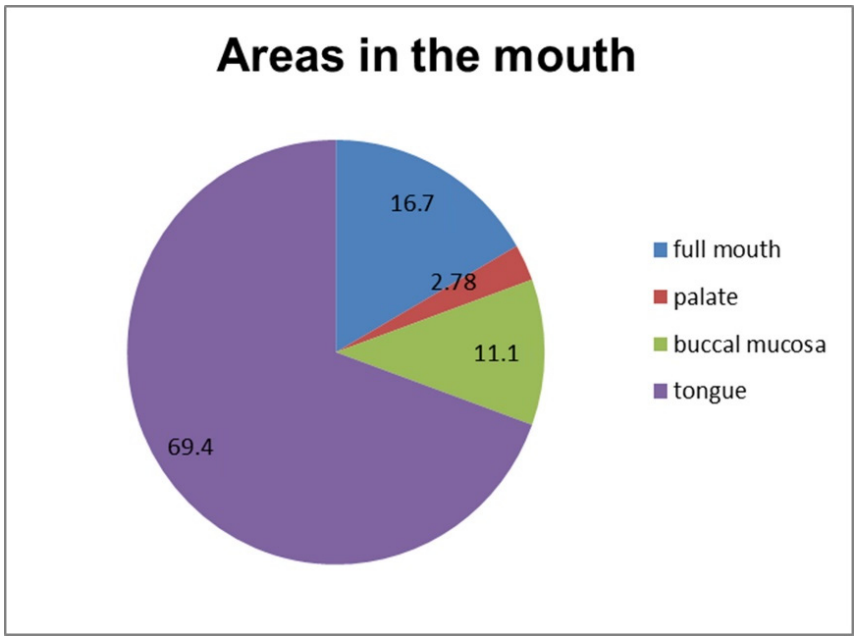

Fig. 5 breakdown of areas in the mouth where salt taste was perceived in the hypertension group.

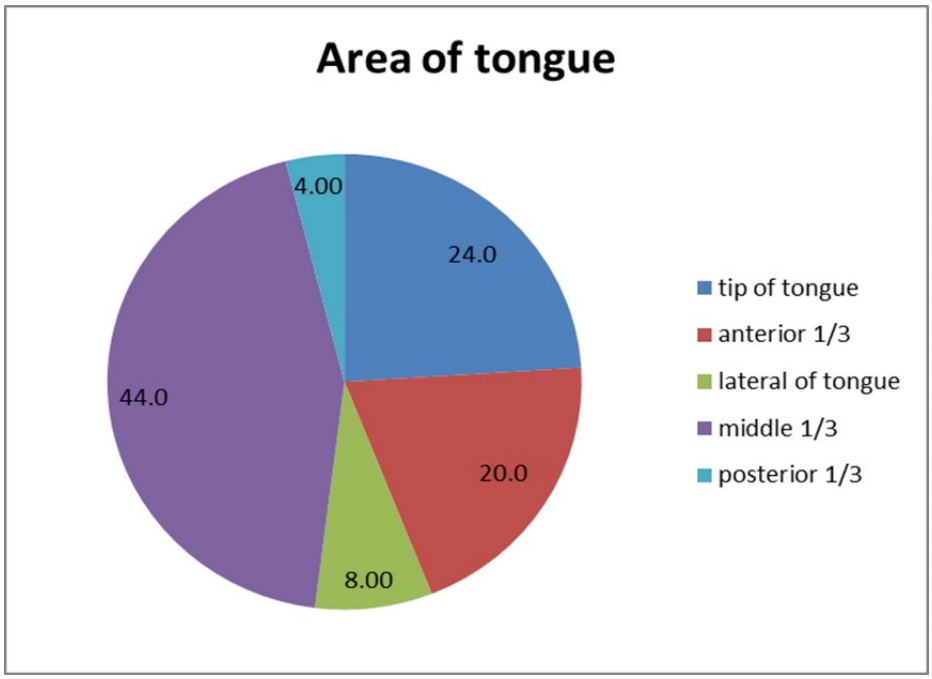

Fig. 6 breakdown of areas of the tongue where salt taste was perceived in the hypertension group.

In this study, salt-recognition threshold (sodium chloride solution 0.25%) was not statistically significant between the groups, meaning that hypertensive participants were still able to spot the salty taste similarly to healthy individuals, and high blood pressure did not relate to this ability, nor had any effect on it. This was also confirmed by other studies. Fischer et al (Fischer et al. 2012) conducted a study on a very large population (2,371 people) and concluded that salt recognition was the same between healthy and hypertensive participants. Another investigation was done by Kim et al (Kim et al. 2017) to evaluate the salt-taste threshold among participants with untreated hypertension. Their results indicated that even these participants still had the same threshold, compared with healthy people.

The tongue was the main part involved in recognizing the salt taste, which was not surprising. In addition, other parts of the oral cavity were also involved. The reason was the presence of taste receptors in several locations in the oral cavity (Breslin and Huang 2006). Regarding the tongue specifically, the middle third of it had the highest percentage of recognition. This could have occurred by chance, especially since this type of report was done subjectively, i.e., reported by the participants and how they felt, which might differ between individuals. On the other hand, it could be related to the presence of Type III taste receptor cells, which are located in the middle area of the tongue, among other areas (Dutta Banik et al. 2020; Finger 2005). Overall, hypertensive, and healthy participants showed similar results with respect to the parts of the tongue and taste recognition, which also implies that high blood pressure does not alter this phenomenon.

Interestingly, this investigation indicated that hypertensive participants showed less preference for the salty taste, compared to healthy people. The reason behind this is the possibility that such participants may have switched to a low-salt diet and over a period of time have adapted to it, leading to a decreased preference for salt. Although the enrolled sample had a wide age range (30-50 years), it has been stated that there was no difference in perception and pleasantness of salty taste between young adults and older adults (Sato et al. 2022). Thus, this factor may not be a contributor to affecting these results. On the other hand, these results were in contrast to the conclusions shown in the study by Chung and Lee (Chung and Lee 2019) which indicated a difference in salt taste preference between hypertensive and normotensive participants. The reason could be the contrasting baseline results, i.e., the difference in recognition threshold between participants with high blood pressure and normal blood pressure, which also contradicted the outcomes of other studies (Fischer et al. 2012; Kim et al. 2017). Furthermore, this might have been related to the fact that in Chung and Lee's trial, females and males were analyzed separately, with females only showing this difference in recognition threshold, as well as a preference of salt taste, whereas males not presenting any differences.

Future studies are indeed required to confirm what is stated in the current study, since it would be of high importance to know whether hypertensive participants show less preference for salty taste, as opposed to healthy individuals, which could further assist these participants in lowering their blood pressure and avoiding the negative effect that arises from high salt intake.

This study is accompanied by certain limitations. No proper calculation of sample size was carried out and the enrolled sample was only proposed to be suitable for the timeline set for this research. This, in turn, did not give the possibility of dividing the participants based on the stage of hypertension, which may also alter the results. With respect to the design of this experiment, neutralizing the mouth between each concentration was done with water, which may not have been effective enough to get the participant's state back to normal. As for the population included, it is important that all participants were Thai, and it is well-known that the Thai population consumes high amounts of spicy food on a daily basis. It has been documented that spicy food intake may reduce salt preference and overall salt intake (Li et al. 2017). This also may have affected the result to a certain degree.

Within its limitations, the present study indicated that both healthy and hypertensive individuals had the same taste recognition threshold, with the middle one-third of the tongue being able to sense it. Conversely, hypertensive participants showed less preference for salty taste, as opposed to healthy people, which could contribute to them keeping their salt intake at a minimum level.

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Patient consent: The procedure was explained to all participants and written consent was obtained from each participant prior to the experiment.

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Ethics approval: This study was approved by Committee in the Ethics of Research in Human Being of Dentistry and Pharmacy Mahidol University Institutional Review Board with Protocol No. MU-DT/PY-IRB 2016/046.1909.

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