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LITERATURE REVIEW

SALT TASTE THRESHOLD AS A DETECTION OF SALT INTAKE IN HYPERTENSIVE INDIVIDUALS

Ambang Rasa Asin sebagai Deteksi Konsumsi Garam pada Individu Hipertensi

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ABSTRACT

Background: High sodium consumption is one of the risk factors for hypertension. Excess salt intake may be affected by an individual's ability to detected taste. However, decreased salt sensitivity can increase consumption of salty foods. **Purpose:** This review aims to analyze the salt taste threshold and its relation to salt intake among hypertensive and normotensive individuals. **Methods:** The review was conducted using five electronic databases and fourteen articles reporting on salt taste threshold, salt intake, and blood pressure. Open access articles, original research, published over the past ten years, and subject's age over eighteen years both healthy and with specific clinical conditions, and have blood pressure data were identified and included in the study. **Results:** There were fourteen studies that measured salt taste threshold through detection threshold and/ or recognition threshold. Ten studies reported salt consumption through Na-FFQ, SQ-FFQ, 24-hour food recall, discretionary salt, adding salt questionnaire, salt use behavior questionnaire, salt preference questionnaire, and sodium excretion. Most studies showed that high salt consumption is higher in the group with high salt taste threshold and high salt taste threshold tends to be more in hypertensive group. The result also showed a significant correlation between salt consumption both through self-reported questionnaire and 24-hour urinary sodium excretion. **Conclusion:** Although the correlation between salt taste threshold, salt intake, and hypertension can be found a matching method with adequate statistical power is needed to get more accurate results.

ABSTRAK

Latar Belakang: *Konsumsi tinggi garam merupakan salah satu faktor risiko hipertensi. Konsumsi makanan tinggi garam mungkin dipengaruhi oleh*

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kemampuan individu dalam mendeteksi rasa. Bagaimanapun, penurunan sensitivitas rasa asin dapat meningkatkan konsumsi makanan asin. ***Tujuan:*** *Tujuan dari kajian sistematis ini adalah untuk menganalisis ambang rasa asin dan hubungannya dengan asupan garam pada individu hipertensi dan normotensi.* ***Metode:*** *Kajian literatur dilakukan menggunakan lima basis data elektronik dengan empat belas artikel melaporkan mengenai ambang rasa asin, asupan garam, dan tekanan darah. Artikel dengan akses terbuka, penelitian asli, diterbitkan selama sepuluh tahun terakhir, dan subyek berusia lebih dari delapan belas tahun baik sehat maupun dengan kondisi klinis tertentu, dan ada data tekanan darah diidentifikasi dan dimasukkan dalam penelitian.* ***Hasil:*** *Terdapat empat belas studi yang mengukur ambang rasa asin melalui ambang deteksi dan/ atau ambang pengenalan. Sepuluh studi melaporkan konsumsi garam baik melalui Na-FFQ, SQ-FFQ, 24-jam pencatatan makanan, penggunaan garam, kuesioner penambahan garam sebelum makan, kuesioner kebiasaan konsumsi garam, kuesioner preferensi rasa asin, dan ekskresi urin. Sebagian besar studi menunjukkan bahwa konsumsi garam lebih tinggi pada kelompok dengan ambang rasa asin yang tinggi dan kelompok dengan ambang rasa asin yang tinggi lebih banyak berada pada kelompok hipertensi. Hasil uji hubungan menunjukkan adanya hubungan yang signifikan antara konsumsi sodium baik menggunakan instrumen pencatatan kuesioner secara mandiri maupun pengukuran ekskresi urin 24 jam.* ***Simpulan:*** *Meskipun hubungan antara ambang rasa asin, asupan garam, dan hipertensi dapat ditemukan tetapi penyeragaman metode dengan kekuatan statistik yang memadai akan memberikan hasil yang lebih akurat.*

INTRODUCTION

Hypertension is a public health problem that is increasing over the years. The World Health Organization (WHO) reported that 1.13 billion adults in the world suffer from hypertension and it is estimated that it will increase to 1.56 billion in 2025 (WHO, 2017). Furthermore, about 82% of adult's hypertension is found in low- and middle-income countries (LMICs), such as Indonesia. The results of the Indonesian Basic Health Research (Riskesdas) in 2018 recorded the national hypertension prevalence was 34.10% with an increase of 8.30% compared to 2013 (Kemenkes RI, 2018).

The cause of hypertension is still uncertain. Most of all adult cases of hypertension worldwide are classified as primary hypertension (Iqbal & Jamal, 2022). Diet and lifestyle habits have a massive risk on primary hypertension as well and high sodium consumption has been reported as a major risk factor. Sodium is a major extracellular cation in the body. Sodium has an important role in many processes, such as controlling plasma volume, maintaining acid-base balance, nerve impulse, and supporting normal cellular homeostasis (Partearroyo et al., 2019). On the other hand, high sodium consumption has a non-supportive impact on blood pressure, such as activation of the renin-angiotensin-aldosterone system (RAAS), fluid retention, increased systemic peripheral resistance, endothelial dysfunction, stiffness of the arteries, and modulation of cardiovascular sympathetic activity (Grillo, Salvi, Coruzzi, Salvi, & Parati, 2019; Youssef, 2022)

Sodium in food is largely ingested as table salt (NaCl). Table salt consists of 40% sodium and 60% chloride with 1 gram of salt equivalent to 393.4 milligrams of sodium (Atmarita, Abas B. Jahari, Sudikno, 2017; Partearroyo et al., 2019). Salt is closely related to palatability enhancers. Salt can reduce water activity so that it can strengthen and increase the volatility of the taste (Puputti, Aisala, Hoppu, & Sandell, 2019). Apart from its palatability function, salt also has a big role in the food industry. Salt has bactericidal (kills bacteria) and bacteriostatic (inhibits the rate of bacterial growth) so it has an important role in maintaining the preservation of food.

Santos et al. (2019) state that packaged foods contribute 75% to sodium consumption in high-economy countries. Results of a systematic review conducted by Bhat et al., (2020) in 34 countries stated that the main source of sodium consumption from many countries in Europe and USA comes from bread and bakery products, cereal and grain. The same result showed that, in high-income countries, the majority of sodium intake comes from food manufacture and during food preparation in fast-food and sit-down restaurant (Campbell et al., 2022). However, high industrial activity and massive globalization have also led to increased packaged food consumption in LMICs.

In their research, Menyanu, Russell, and Charlton (2019) mentioned that LMICs have dietary patterns transition from traditional staples toward bread, meat products, salted meat and fish, condiments, sauces, spreads, pizza, and seafood that are high in saturated fat, trans fat, sugar, and salt. Individual Food Consumption Survey in Indonesia stated that the major of sodium consumption sources are spices and preparations including salt, but followed by an increase of cereals and cereals product, and meat and meat product (Atmarita, Jahari, & Sudikno, 2017). The increase in the food product will indirectly be one of the triggers for excessive salt consumption behavior. Santos et al. (2019) show that most countries consume salt over WHO recommendations (>5 grams/day). Campbell et al., (2022) also describe that average global sodium intake is about 10 gram/ day with the higher salt consumption coming from Asia. Indonesia experiences the same problem with an average salt consumption of 6.16 grams per day and 58.8% consumed salt more than 5 grams per day (Farapti, Fatimah, Astutik, Hidajah, & Rochmah, 2020).

Food consumption is influenced by several factors, one of them is the condition of the taste buds and changes in the composition of saliva (Puputti et al., 2019). The suboptimal condition of the taste buds can cause changes in the perception and sensitivity of a taste, including saltiness. The decrease in taste sensitivity will generally begin at the apical and lateral part of the tongue, so the taste sensations that are affected first are sweet and salty. Decreased salt sensitivity indirectly increases the salt taste threshold (STT), which is the lowest salt concentration a person can detect. When the tongue's ability to detect salty tastes decreases, it will unconsciously cause a tendency to consume foods high in sodium (Riis et al., 2021). Liu et al. (2018) also showed a significant difference in salt consumption between no altered perception and taste and/ or smell alteration perception groups. When it happens persistently it can increase the risk of hypertension. This literature review aims to analyze the salt taste threshold and its relation to salt intake among hypertensive and normotensive individuals.

METHODS

The literature review search consists of four electronic databases: PubMed, SpringerLink, ScienceDirect, and Google Scholar. The keywords used for each search comprised three themes namely "salt taste threshold," "salt taste sensitivity," "sodium intake," "blood pressure," and "hypertension." Examples of search threads used for PubMed are (salt taste threshold OR salt taste sensitivity) AND (salt intake) AND (blood pressure OR hypertension). Other relevant articles are obtained by manually searching the article references taken. All titles and abstracts are screened based on criteria published during the last 10 years and are a type of research article. Full text and open access articles are examined for eligibility criteria. The inclusion criteria were human-based research, adult or more than 18 years old, having blood pressure (BP) data, and using a saline solution as a STT measurement method. The exclusion criteria were followed by animal studies, <18 years old for subjects, not having blood pressure data, and not using NaCl solution as salt taste measurement.

The author carried out data extraction and synthesis of the articles included in this literature review. The information extracted from each article included the author, study population (number of subjects, age, and clinical condition), salt taste measurement and salt solution conducted during the study, salt intake assessment, and differences in STT and salt intake in hypertension and normotension group. Studies were presented to analyze about STT with salt consumption, STT in hypertension and normotension group, and salt intake in hypertension and normotension group.

RESULTS

Figure 1 shows the flowchart of this study. In total, 28,010 articles were identified from five databases. Of these results, 12,197 were excluded during the screening of abstracts and titles, 12,205 articles were incomplete and not open access, and 5,594 journals were not compatible with inclusion criteria. Finally, 14 articles that met all of the criteria were included in this review.

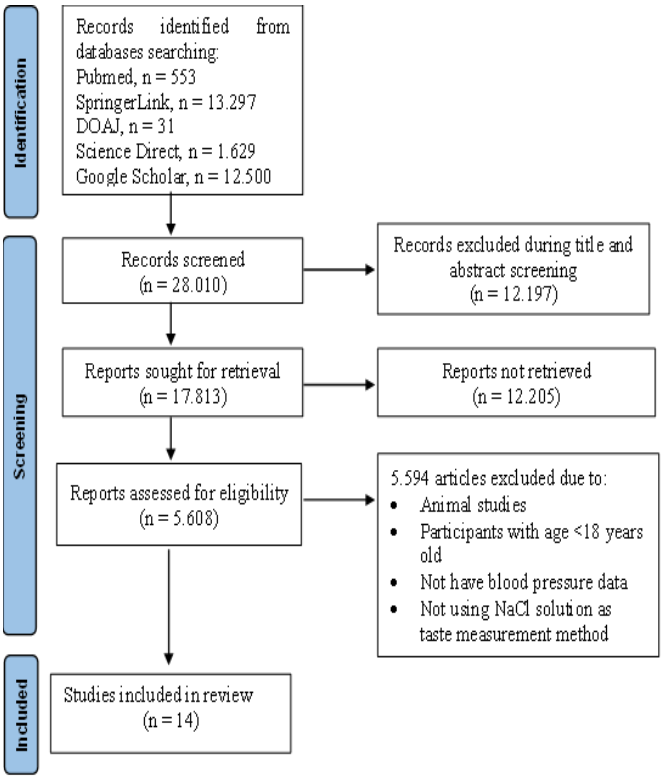

Figure 1. PRISMA flowchart

Subject Characteristic

Fourteen studies that examined STT and hypertension had an age between 18 - 78 years. The most age categories are old adults with an average age of more than 45 years (Amen, 2015; Azotea, Cruz, & Barcelon, 2013; Cho, Kim, Jeong, & Kim, 2016; Kim, Ye, & Lee, 2017; Piovesana et al., 2013; Son et al., 2015; Veček et al., 2020), followed by young adults or 17-30 years old (Martinelli, Conde, de Araújo, & Marcadenti, 2020; Tjahajawati, Rafisa, Murniati, & Zubaedah, 2020), middle–age adults or 31-45 years old (Adolf et al., 2021; Fayasari & Cahyani, 2022, and elderly or up to 60 years old (Kubota et al., 2018; Torigoe et al., 2019; Xue et al., 2020).

Apart from hypertension, several articles chose the subject of smoking, kidney disease, and heart disease. A total of seven studies divided the subjects into hypertensive (HT) and normotensive (NT) categories (Adolf et al., 2021; Amen, 2015; Azotea et al., 2013; Fayasari & Cahyani, 2022; Kim et al., 2017; Piovesana et al., 2013; Son et al., 2015), one study divided into Coronary Heart Disease (CHD) patients with hypertension and non-CHD (Xue et al., 2020), one study in peritoneal dialysis (PD) (Torigoe et al., 2019), and healthy individuals (Cho et al., 2016; Kubota et al., 2018; Martinelli et al., 2020; Veček et al., 2020).

Measurement of Salt Taste Threshold

Fourteen studies examined STT as a detection threshold (DT) and/ or recognition threshold (RT). DT is the lowest concentration that can be detected while RT is the concentration that can be recognized well. STT is measured using a saline solution with a variety of concentrations. Most measurements use the whole mouth taste method and the other two use salt-impregnated taste strips (Kubota et al., 2018; Torigoe et al., 2019). Seven studies used the ascending saline solution method (Amen, 2015; Azotea et al., 2013 Kubota et al., 2018; Martinelli et al., 2020; Tjahajawati et al., 2020; Torigoe et al., 2019; Son et al., 2015; Veček et al., 2020) and others using paired salt taste measurement (Adolf et al., 2021; Cho et al., 2016; Fayasari & Cahyani, 2022; Kim et al., 2017; Piovesana et al., 2013).

Salt Taste Threshold, Salt Intake, and Blood Pressure

Table 1 shows that sodium intake was higher in high STT subjects. Martinelli et al. (2020) report a difference in dietary sodium of about 635 mg/ day between high and normal STT. The same amounts and concentrations also showed similar results in different age groups. Piovesana et al. (2013) state that there is a correlation between DT and RT with total sodium intake in the old adult group ($p = 0.0015$ and $p = 0.017$). The study found that up to 60% of total sodium came from discretionary salt. A different study also showed that subjects with higher STT tended to add salt before tasting (Cho et al., 2016; Veček et al., 2020).

Based on the research, 24-hour urinary sodium excretion was lower in normal STT (Cho et al., 2016; Kim et al., 2017; Piovesana et al., 2013). In the elderly, Kubota et al. (2018) also found that the estimated of daily salt intake based on 24-hour urinary sodium excretion would increase according to the high STT. But, different results found that sodium urine excretion in the elderly is lower in high STT (Torigoe et al., 2019). The results might be differences because of measurement methods and participant conditions. Kubota et al. (2018) used 24-hour urinary sodium excretion instead of spot urine and used healthy subjects. Torigoe et al. (2019) subjects were PD patients thus the amount of salt urine excretion might be affected by low-salt diet from the hospital. Healthy individuals who smoke have a higher STT than nonsmokers. Tjahajawati, Rafisa, Murniati, and Zubaedah (2020) stated that there was a positive correlation between STT and SBP which was influenced by smoking habits (p-value = 0.009, r = 0.306). The more and longer cigarettes are consumed will have an impact on the increase in STT. This also suggests that men have a lower sensitivity because most of the population smokes when compared to women (Son et al., 2015).

Fourteen studies have shown that individuals with high BP have a higher STT than normal, although some claim it is not significant (Fayasari & Cahyani, 2022; Kim et al., 2017; Kubota et al., 2018; Son et al., 2015). The results conducted by Kim et al. (2017) in old adults stated that there was no significant difference between DT and RT in the hypertensive and normotensive groups (p-value= 0.900 and p-value = 0.823) but a study in the same age group stated that there was a significant difference in RT in the HT and normal individuals (Amen, 2015). One of the differences between the two is subjects in the study. Kim et al. (2017) did not recorded antihypertensive drugs but Amen (2015) included that drugs in case group.

In young adults showed significant differences between STT and BP (Martinelli et al., 2020) and in the elderly showed the opposite (Kubota et al., 2018). Studies suggest that there is a significant correlation between sodium intake and BP. These results were found using the SQ-FFQ and 24-urinary sodium excretion measurements in the healthy old adult (Fayasari & Cahyani, 2022; Kim et al., 2017). The results showed that HT group had an average sodium consumption of 2,620 mg and the healthy group had 520 mg lower (Fayasari & Cahyani, 2022). 24-hour salt recall conducted by Adolf et al. (2021) also showed that the HT group had a higher salt consumption than NT (6.7 [4.9-8.3] vs 6.4 [4.9-8.7]). The results of 24-hour urine sodium measurement in subjects with antihypertensive drugs showed that there was a significant difference between 24-hour urinary sodium excretion in the HT and NT (Adolf et al., 2021; Kim et al., 2017). Unlike, Piovesana et al. (2013) showed no difference between 24-hour sodium urine excretion in NT and HT groups ($p < 0.05$). Different results were shown with differences subjects where Piovesana et al. (2013) used hypertensive individuals with stable anti-hypertensive drug regimens for at least one month.

DISCUSSION

The results showed that there were two types of STT measurements, namely whole-mouth (Adolf et al., 2021; Amen, 2015; Fayasari & Cahyani, 2022; Cho et al., 2016; Kim et al., 2017; Kubota et al., 2018 Martinelli et al., 2020; Piovesana et al., 2013; Son et al., 2015;Tjahajawati et al., 2020; Veček et al., 2020) and salt-impregnated taste strips (Kubota et al., 2018; Torigoe et al., 2019). Salt-impregnated taste strips eliminated the drawbacks of the whole-mouth approach. The test takes less time, requires no specific expertise to administer, and does not involve the preparation of a salt solution. The use of the whole-mouth method requires preparation procedures such as an oral hygiene test (Cho et al., 2016), and not eating and brushing teeth for an hour before the test (Piovesana et al., 2013) to get better results. Food residues left in the oral cavity can affect the taste quality and the use of toothpaste with Sodium Lautyl Sulphate (SLS) can suppress the bitter taste and reduce the intensity of salty taste when testing (Piovesana et al., 2013).

24-hour urinary sodium excretion is the gold standard for estimated sodium intake because 90% of ingested sodium is eliminated in the urine. However, the use of this method is a little complicated and the subject may forget to collect urine periodically, making the results inaccurate. Although the results of the study showed that 24-hour urinary sodium excretion in the high STT group was higher than in the normal STT group, it turned out that the condition of the subjects gave slightly different results. Urinary sodium excretion was lower in the high STT group (DT $\geq$ 0.8 mg/cm^2 and RT $\geq$ 1.0 mg/cm^2). Chronic Kidney Disease (CKD) and End-Stage Renal Disease (ESRD) patients are prone to taste alteration due to decreased saliva composition, increased uremia, which affects decreasing taste bud and nerve regeneration in the sense of taste, and zinc deficiency. It is necessary to include oral cavity conditions such as several of taste buds, salivary conditions, and dry mouth conditions in the inclusion criteria not shown in this study (Torigoe et al., 2019). In addition, recording the habit of consuming cigarettes is also important as an assessment of the condition of the oral cavity. The nicotine content in cigarettes can cause a decrease in taste cells so that taste buds become smaller. TAR, aldehydes, phenols, cadmium, carbon monoxide, and polycyclic aromatic hydrocarbons can cause irritation and inflammation of the salivary glands. For this reason, the recording of cigarette consumption needs to be written not many of which are attached to this study (Adolf et al., 2021; Azotea et al., 2013; Fayasari &

Cahyani, 2022; Kim et al., 2017; Martinelli et al., 2020; Son et al., 2015; Torigoe et al., 2019).

The differences in STT in the HT and NT groups without comorbid were found in the young adult (Martinelli et al., 2020; Tjahajawati et al., 2020), old adult (Amen, 2015; Piovesana et al., 2013; Veček et al., 2020), but not found in elderly (Kubota et al., 2018). As we get older, the body will experience functional degeneration that will not be possible to avoid one of the reasons for the decrease in the number of taste buds. These results are confirmed in a study conducted by Amen (2015) which shows that age has an influence on taste disorder in both HT and NT categories. A decrease in the number of taste buds can lead to an increase in the STT that can cause a person to consume a greater amount of salt to adjust the perception of the taste they have (Cho et al., 2016; Veček et al., 2020).

Furthermore, DT is the lowest concentration of the solution that can be detected, which allows a large space of measurement error. RT, which has a smaller measurement error due to the confirmation, was still less accurate in determining the standard threshold of salty taste. For example, Xue et al. (2020) stated RT when subjects can describe the taste, Veček et al. (2020) assumed that RT is the lowest concentration when subjects can describe twice, and Martinelli et al. (2020) made a point by increasing solution until the subject correctly identified the taste. Then, the concentration will be decreased until the subject makes an error and RT is determined by the concentration of the solution before the error. The differences result in elderly STT which may be related to differences in STT cut-offs. Xue et al. (2020) specified RT was high when above 0.05 M, Torigoe et al. (2019) identified DT was high when $\geq$ 0.8 mg/cm^2 and RT $\geq$1 mg/cm^2, and Kubota et al. (2018) when RT $\geq$1.0%. Furthermore, the recording of the use of drugs also needs to be taken considering that hypertension with regular use of antihypertensive drugs and untreated hypertension will affect taste impairment (Amen, 2015; Kim et al., 2017). Atenolol is a type of beta-blocker that can reduce the salivary rate in the submandibular and sublingual glands. Captopril is an antihypertensive drug and plays a role as an Angiotensin Converting Enzyme (ACE) inhibitor. Since the ACE enzyme is a zinc-dependent enzyme, the drug's suppression of ACE may have an impact on the zinc level of the ACE protein in the salivary glands cell, which could affect in impair taste. So, the antihypertensive drug has to be recorded to minimize bias.

The method of measuring salt intake with the SQ-FFQ questionnaire showed similar results with 24-hour urinary excretion (Fayasari & Cahyani, 2022; Kim et al., 2017). SQ-FFQ allows more precise results to predict salt intake than Na-FFQ because it takes into account the weight of the food. Determination of sodium consumption by a single self-reported method highly biased value of the actual results. FFQ only captures habitual food intake not the amount of intake while 24-hour dietary recalls just reflect food intake on the previous day. A combination of several self-measurement methods is necessary to avoid bias in the results of the study. The results of the study using the total intake of several measurement methods compared with the estimated intake of salt from urine get significant results (Piovesana et al., 2013). When viewed from the total, the estimation of salt consumption using FFQ in the normotensive group is 2.2 ± 1.9 gr salt/day while the estimated calculation of urine is 9.8 ± 4.5 gr salt/day. The same results were also seen in the hypertension group indicating that the estimated salt consumption of the FFQ was 1.5 ± 1.6 gr salt/ day meanwhile excretion of sodium urine is 10.9 ± 4.3 gr salt/day.

Similar results were obtained when combining salt consumption through FFQ, 24-hour food recall, and discretionary salt with 9.6 ± 3.1 gr salt/day in the hypertensive group and 12.1 ± 6.2 gr salt/day in the normotensive. So, it can be said that the use of FFQ alone will give lower results than the fact. Overall salt consumption through 24-hour urinary sodium excretion was higher in the hypertensive group except in individuals taking medication. The use of drugs in hypertensive patients such as diuresis, mainly high-ceiling / loop diuretics, can reduce sodium reabsorption by 20% compared to normal people who are only 0.4% so it will increase sodium levels in urine. Consumption of ACE inhibitor drugs can also inhibit the formation of Angiotensin II in kidneys and increased bradykinin, resulting in reduced sodium and water retention. However, estimation of salt intake showed that both the HT and NT groups were higher than the recommendation (5 grams per day).

Table 1.
Salt Taste Threshold, Salt Intake, and Hypertension

Authors	Participants	Age (years)	Taste Measurement	Salt Intake Assessment	Key Findings
Fayasari & Cahyani (2022)	100 subjects (50 HT & 50 NT)	18 – 60	Paired difference test with sterile salt solution. Salt concentration at 0.58, 1.87, 5.84, 18.7, 58.44 g/L.	SQ-FFQ	- Sodium intake was associated with HT ($p = 0.002$) - No association between DT and HT ($p > 0.05$) - DT in HT subjects were slightly higher than NT
Adolf et al. (2021)	80 subjects (40 HT & 40 NT)	28 – 60	Paired difference test with distilled water at 0.5, 1, 2, 4, 8, 16, 32, 64, 128, 256 mmol/L.	24-hour salt recall and 24-hour sodium urine excretion	- HT have higher STT and 24-hour salt recall than NT - 24-hour sodium urine excretion was significantly different in HT and NT group ($p < 0.001$)
(Xue et al., 2020)	2103 subjects (1.220 non-CHD & 883 CHD)	18 – 79	Graded solution of saline. Concentration from 0.025 to 0.4 mol/L.	NA	- RT was associated with HT ($p < 0.001$) - CHD patient has higher STT than control
Martinelli et al. (2020)	104 subjects (healthy individuals)	18 – 59	Ascending saline solution from 0.004, 0.008, 0.015, 0.03, 0.06, 0.120, 0.25, 0.5, and 1 M.	Na-FFQ and 24-hour food recall	- Sodium intake was lower in normal STT ($p = 0.001$) - Mean of SBP and DBP were lower in normal STT ($p < 0.001$)
Veček et al. (2020)	2798 subjects (general population)	> 18	Graded saline solution from 0.00821, 0.01369, 0.02281, 0.03802, and 0.06337 M.	Adding salt questionnaire	- Both of SBP and DBP were differ between low, medium, dan high STT ($p < 0.001$) - High STT had adding salt habit more than medium and low
Tjahajawati et al. (2020)	73 female subjects (24 smoker & 49 non-smoker)	18 – 24	Ascending saline solution test from 0.005 – 0.05M	NA	- STT was significantly correlated with SBP ($p = 0.026$) - STT and SBP was influenced by smoking habits ($p = 0.009$)
Torigoe et al. (2019)	22 subjects (PD patient)	55 – 78	Increasing salt-impregnated taste strip from 0.6, 0.8, 1.0, 1.2, 1.4, and 1.6 mg/cm^2	Spot sodium urine	- No difference between BP in normal and high STT ($p > 0.05$) - Normal STT have more salt excretion than high STT
Kubota et al. (2018)	892 subjects (healthy community)	40 – 74	Ascending salt-impregnated taste at 0, 0.06%, 0.08%, 1.0%, 1.2%, 1.4%, 1.6%	24-hour urinary sodium	- No difference of BP and daily salt intake among the three groups of STT ($p > 0.05$)
Kim et al. (2017)	199 subjects (133 HT & 22 NT)	> 18	Paired difference test with blank sample in 0.00488, 0.00977, 0.01953, 0.03906, 0.07813, 0.15625, 0.31250, 0.62500, 1.25000, 2.50000, 5.00000, 10.00000, and 20.00000 g/mL.	24-hour urinary sodium	- No difference between STT in HT and NT group ($p > 0.001$) - Mean 24-hour urinary sodium higher in HT group ($p = 0.011$) - No correlation between 24-hour urinary sodium and STT - 24-hour urinary sodium was correlated to SBP
Azotea et al. (2013)	50 subjects (25 HT & 25 NT)	18 – 64	Ascending NaCl solution test. NaCl concentration at 0.002, 0.004, 0.008, 0.016, 0.032, 0.064, 0.128 and 0.256 M.	NA	- HT subjects have higher DT (0.03 M) than NT (0.02 M)

(Continued)

Table 1
Continued

Authors	Participants	Age (years)	Taste Measurement	Salt Intake Assessment	Key Findings
Cho et al. (2016)	108 subjects (64 from Myanmar & 67 from Korea)	> 18	Paired one of NaCl solution with two deionized water (3-Alternative Forced Concentration). Saline solution at 0.01, 0.025, 0.05, 0.075, 0.10, 0.125, 0.15, 0.2, 0.3%, 0.4, and 0.5%.	Salt usage behavior questionnaire, salt preference questionnaire, and spot urine sodium.	- Myanmar have higher salt preference, salt usage behavior, and spot urine sodium - DT and STT were higher in Myanmar ($p<0.001$ and $p<0.01$) - Means of SBP and DBP were higher in Myanmar. - DT and RT correlated with SBP ($p = 0.005$ and $p = 0.041$)
Amen (2015)	200 subjects (100 HT & 100 NT)	34 – 75	Five solutions of NaCl graded from low to high. Concentrations start at 0.01, 0.032, 0.1, 0.32, and 1 M	NA	- HT have higher STT than NT ($p = 0.001$) - HT and NT in older age had more salty taste disturbance than younger ($p = 0.018$ and $p = 0.009$)
Son et al. (2015)	120 subjects (80 HT & 40 NT)	> 35	Ascending saline test at 0.00488, 0.00977, 0.01953, 0.03906, 0.07813, 0.15625, 0.31250, 0.62500, 1.25000, 2.50000, 5.00000, 10.00000, 20.00000 g/mL.	24-hour urinary sodium excretion	- HT group had a slightly higher STT than NT but not significant ($p > 0.05$) - Men in HT and NT group have higher STT - Mean 24-hour urinary sodium excretion was higher in HT group
(Piovesana, Sampaio, & Gallani 2013)	108 subjects (54 HT, 54 NT)	30 – 65	Eight paired difference tests with distilled water. Salt solution concentration at 0.002, 0.004, 0.008, 0.016, 0.032, 0.064, 0.128 and 0.256 M.	Self-reported of salt intake (discretionary salt, 24-hour food recall, Na-FFQ) and 24-hour urinary sodium excretion	- DT and RT were lower in NT ($p = 0.001$ and $p= 0.002$) - Total sodium intake in NT was lower than HT ($p = 0.046$) - DT and RT were correlated with total intake ($p = 0.015$ and $p = 0.017$) - No association between DT and RT with urinary sodium excretion.

NA: Not Applicable; HT: Hypertension; NT: Normotension; STT: Salt Taste Threshold; DT: Detection Threshold; RT: Recognition Threshold; PD: Peritoneal Dialysis; Na-FFQ: Natrium- Food Frequency Questionnaire; FFQ: Food Frequency Questionnaire; NaCl: Sodium Chloride, M: Molar; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; CHD: Coronary Heart

Research Limitations

This study has limitations in the number of subjects and diverse research methods. In addition, only a small percentage of studies recorded smoking habits even though the chemicals contained in cigarettes have important implications on oral cavity condition. A way that can be used to minimize the difference in results is to provide more standards before testing, such as not eating, drinking sweet drinks, and brushing teeth one hour before the implementation of the study. Determining the amount of sodium intake using questionnaires independently is better done by combining several methods such as short-term intake, eating habits, and discretionary salt consumption habits.

CONCLUSION

The saltiness threshold has a role in influencing salt consumption mainly from the state of taste, age, and satisfaction with the taste stimuli received. Daily salt intake was either measured through self-reported measurements using questionnaires and spot urine or 24-hour urine excretion which showed higher values in the group with a high salt taste threshold and high blood pressure. Despite its limitations, the results of this review may have important practical implications regarding the salt taste threshold as detection of salt consumption and its relationship to blood pressure. However, consideration of the number of subjects, age, and external factors such as the use of medications, disease conditions, and the specific diet being followed allow for differences in results compared to healthy individuals.

CONFLICT OF INTEREST

No conflict of interest in this study.

AUTHOR CONTRIBUTION

ANS doing conceptualization, search, data restriction, methodology, and writing-original draft. FF participated in conceptualization, supervision, editing, and reviewing. NMN participated in supervision and review. All authors read, give critical feedback, and approved the final version of the manuscript.

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