

Knowledge, attitude, practice, and salt intake on obesity-related hypertension among institutional older adults: a comparative cross-sectional study

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ABSTRACT

Introduction: Obesity-related hypertension (OB-HT) is a significant health issue in older adults, with high prevalence rates globally. However, older adults in institutions often fail to adhere to dietary guidelines, resulting in poor nutritional habits and excessive salt intake. This study aims to assess the differences in knowledge, attitudes, practices, and salt intake among older adults with and without OB-HT in an institutional setting.

Methods: A comparative cross-sectional study was conducted among 50 older adults (25 with OB-HT and 25 controls) in a nursing home in Indonesia. A visual-based questionnaire assessed sodium knowledge and attitude. Salt taste sensitivity was evaluated using a ranked salt intensity test on chicken soup formulations with varying salt levels (0.612–1.125 g/100 mL), and salt preference was measured using a hedonic sensory test. Energy and sodium intake were estimated using a semi-quantitative food frequency questionnaire (SQ-FFQ). Statistical analysis included chi-square, t-test, and Mann-Whitney U test ($p < 0.05$).

Results: There was no significant difference in sodium-related food knowledge; however, males had lower sodium knowledge scores ($p = 0.029$). Attitudes toward high-sodium foods differed significantly only among males ($p = 0.023$). Older adults with OB-HT exhibited significantly lower salt taste sensitivity, particularly among males ($p = 0.043$), and demonstrated a stronger preference for higher sodium concentrations in food ($p = 0.046$). Notably, sodium intake differed only among females ($p = 0.047$).

Conclusions: This study highlighted the relationship between OB-HT and dietary habits, emphasizing the need to identify sex-specific differences in knowledge, attitudes, and practices regarding salt intake among older adults.

Keywords: hypertension, older adults, obesity, salt, taste

Introduction

The high prevalence of Obesity-related hypertension (OB-HT) remains a challenge, as older adults mainly residing in institutional settings fail to adhere to the dietary guidelines provided in their menus. Some studies reported that the daily menus offered by nursing homes in certain countries surpass the recommended levels of fat and sodium but fail to meet micronutrient requirements (Lacey *et al.*, 2018; Aytekin Sahin and Caferoglu, 2022; Grajek *et al.*, 2022). Menu assessments

conducted in nursing homes in Indonesia revealed that sodium intake exceeded the recommended level by 177%, whereas only one-fifth of the recommended potassium intake was met (Farapti, Wangi, and Adiningsih, 2023). Sodium plays a crucial role in various physiological processes (Partearroyo *et al.*, 2019). Excessive sodium intake can activate the renin-angiotensin-aldosterone system (RAAS), inducing endothelial dysfunction, promoting fluid retention, and increasing systemic peripheral resistance that is closely linked with



hypertension (Grillo *et al.*, 2019). Salt, as the most common dietary sodium source, is also closely associated with enhancing palatability by reducing water activity, thereby intensifying and amplifying flavor volatility (Partearroyo *et al.*, 2019). However, uncontrolled OB-HT and excessive salt intake can extensively affect overall health, and self-control becomes crucial.

A previous study conducted by Nasution *et al.* (2021) discovered that a considerable proportion of the older adult population in Indonesia is experiencing inadequate nutrition, which has been linked to a lack of proper nutritional knowledge (Nasution *et al.*, 2021). Similarly, another study found that older adults with limited understanding of salt exhibited poor salt habits (Haron *et al.*, 2021). Furthermore, recent studies have shown a positive correlation between salt-related knowledge, attitudes, practices, and salt intake (Rusmevichientong *et al.*, 2021), which is inversely associated with 24-h urinary sodium excretion (Fan *et al.*, 2022). It has been suggested that increasing knowledge, attitudes, and practices by 1 point can reduce 24-h urinary sodium excretion by 0.851 mmol, benefiting individuals with hypertension (Fan *et al.*, 2022). Healthcare professionals in nursing homes can effectively reduce sodium intake and promote healthier eating among older adults through education and dietary interventions. Nurse-led initiatives that enhance nutrition literacy, particularly regarding salt, are crucial for preventing and managing OB-HT, ultimately improving nutritional behaviors and health outcomes (Ajiboye *et al.*, 2021; Yuan *et al.*, 2023; Setyoadi *et al.*, 2024).

Understanding the importance of reducing salt intake and several physiological factors during aging can help older adults comprehend the risks associated with hypertension and other related diseases and adopt healthy behaviors, including controlling salt intake, thus increasing well-being and life expectancy. To our knowledge, limited research has been conducted in this field in Indonesia, emphasizing the importance of conducting this study. Therefore, this study aimed to assess differences in knowledge, attitudes, and practices regarding salt intake between older adults in institutions with OB-HT and healthy controls. This study is expected to augment the understanding of dietary habits among older adults and serve as a basis for designing sustainable and impactful health initiatives, especially regarding non-communicable diseases.

Materials and Methods

Study Design and Subjects

This comparative cross-sectional study was conducted from July to December 2023 among older adults in the institutional care setting in Surabaya, Indonesia. All variables were collected at the same time, and this study aims to compare the differences in knowledge, attitudes, practices, and salt intake among

older adults with and without OB-HT, so the design was chosen. Of the total population of 171 older nursing home residents, the criteria study was used to select the eligible respondent. The inclusion criteria: aged over 60 years, able to communicate effectively, in good health, and not bedridden. Older adults with cognitive impairment, edema, severe digestive disorders, acute influenza, and olfactory disorders were excluded. Finally, as ninety respondents met the study criteria and the next step was screening subjects based on blood pressure and anthropometric measurements to determine case and control group.

The sample size was determined using G*power statistical software version 3.1.9.7 with the assumption of comparing the mean and standard deviation of sodium intake between hypertensive and normotensive (Farapti *et al.*, 2017, and CDC, 2013). Input parameters were effect size of 0.8785, a precision of 0.05, power ($1-\beta$) of 80%, with a 95% level of confidence, and an allocation ratio of 1:1 which resulted in a minimum sample size of 22 subjects for each group. Based on blood pressure and anthropometric measurements, 25 subjects who displayed both obesity and hypertension were categorized in the OB-HT or case group, so all subjects were involved in this study. Meanwhile, the non-OB-non-HT (control) group consisted of 25 subjects, selected by simple random sampling. The study sample comprised 50 participants, divided into two groups: OB-HT ($n = 25$) and non-OB-HT ($n = 25$). [Figure 1](#) describes the flowchart of the study design, including the operational framework for sample selection.

Obesity-Related Hypertension

The OB-HT and control groups were classified according to body mass index (BMI) and blood pressure data. Anthropometric measurements were performed using an SECA 213 GEA portable stadiometer (SECA GmbH & Co. KG, Hamburg, Germany) to assess body height, and a Karada Scan HBF-375 (OMRON Healthcare Co., Kyoto, Japan) was used to determine body weight. BMI was calculated by dividing the body weight in kilograms by the square of the height in meters, resulting in a classification of obesity if BMI was ≥ 25 kg/m² (Lee *et al.*, 2018). Blood pressure was assessed using an OMRON HEM-7201 digital sphygmomanometer (OMRON Healthcare Co., Kyoto, Japan) and classified as hypertension if systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg at measurement or use of antihypertensive drugs regularly (Bell, Twiggs, and Olin, 2015). Subjects in the OB-HT group displayed both obesity and hypertension, whereas those in the non-OB-HT group displayed neither.

Study Measurement

This study examined participant characteristics, including age, sex, education level, length of stay in the nursing home, history of illness, medication

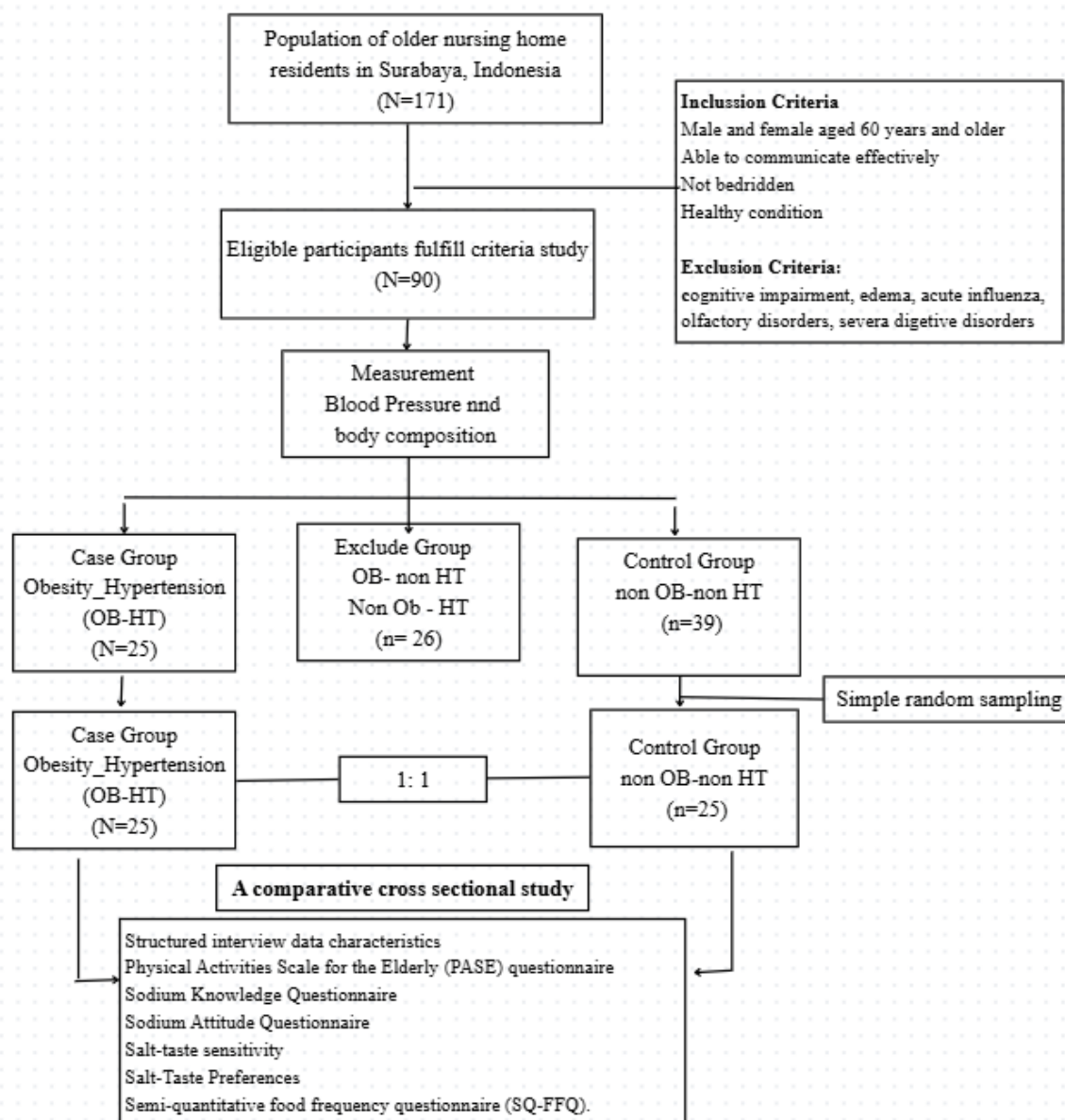


Figure 1. Flowchart of the study design

consumption, and physical activity level. Physical activity was assessed using the Physical Activities Scale for the Elderly (PASE) questionnaire, which was then classified as good if the score was ≥ 40 and poor if the score was < 40 (Logan *et al.*, 2013). An updated scoping review analyzing the PASE questionnaire from 35 countries reported that the PASE was widely used in a variety of clinical populations and geographical locations. The PASE has been culturally adapted to several populations and evaluated for its reliability and convergent validity (D'Amore *et al.*, 2024). Furthermore, the thesis by (Hasanah., 2023) proved the Indonesian version of the Physical Activity Scale for The Elderly is a valid and reliable questionnaire in assessing the physical activity of the elderly in Indonesia Validated questionnaires assessed sodium knowledge and attitudes, while salty taste sensitivity and preferences were evaluated using a

food formulation. OB-HT was determined by anthropometric and blood pressure measurements.

Sodium Knowledge Questionnaire

Knowledge of the sodium source/salt intake in food was evaluated by showing 20 food pictures. Ten images depicting high-sodium foods such as soy sauce, tomato sauce, cassava chips, shrimp paste, anchovies, cheese, salted eggs, canned corned beef, and seasoning ($\geq 20\%$ daily value). Low-sodium foods like tomatoes, potatoes, carrots, lettuce, green beans, soybeans, young coconut, fresh cow's milk, melon, and banana ($\leq 5\%$ daily value) were taken from the Indonesian Food Composition Table 2017 (Ministry of Health, 2017). The participants were asked to tick 10 pictures they considered high-sodium sources. Ratings were based on accuracy, with a perfect score of 100 for correctly identifying all ten images. Proficiency was classified as good (≥ 70), fair (50–70), and

poor (<50) (Alhazmi *et al*, 2024; Haron *et al*, 2021). Furthermore, its reliability was tested using Cronbach's alpha values for attitudes (0.941), indicating that the questionnaire was reliable.

The picture questionnaire was administered to the elderly with low educational backgrounds and difficulty reading and writing. Twenty pictures were displayed to make it easy to understand and apply by the elderly. The sodium knowledge question focused only on the source foods of sodium. All subjects were given information about the questionnaire, then they were asked to choose, by clicking, ten pictures with high sodium content. This study set two food groups specifically that contrary each other, The one group was source foods of high sodium low potassium, another group was low sodium and high potassium food. Since food sources of potassium contain fruit, vegetables, and nuts, which are in contrast to high-sodium foods, it should be easy to choose the correct pictures if subjects understand this concept. This novelty method can be applied to illiterate older individuals by utilizing familiar food pictures from their daily lives.

Sodium Attitude Questionnaire

The same as the sodium knowledge questionnaire, the sodium attitude questionnaire was displayed by image or picture in order to make it easy to be understood by the elderly independently. The picture questionnaire included the daily foods consumed by subjects. The questionnaire was developed through some activities. First of all, two expert nutritionists observed, recorded, and took photos of all the menus served by cooks in the nursing home. While conducting in-depth interviews with cooks, the nutritionists recorded meal composition, ingredients, portions, cooking methods, and salt content, for calculating sodium content of the menu and making list the highest to lowest of sodium content sequentially. Moreover, some donations brought some food for all elderly in nursing home 1-2 times a week regularly, so menus and its sodium content also recorded, for example cheese cassava and crispy fried tofu.

Previous study concluded most researchers usually applied fully labeled scales to assess attitude; however, older respondents differ from younger respondents in terms of ability to translate behaviors or attitude into the given scales of questions. Furthermore, institutionalized residents may encounter difficulties with survey questions because they are distracted by the meaning or emotional content of the words (Schanze, 2021). Therefore, our study arranged a simple picture question about sodium attitude by asking whether subjects prefer higher sodium food to its lower. The sodium attitude questionnaire consisted of 10 questions; three attitude questions asked whether subjects like to add soy sauce, like to add chili sauce, and like to add sauce/spices. Meanwhile, seven questions about preferring salted eggs over boiled eggs; choosing sausage soup over chicken soup; choosing stir-fried water spinach over bean sprout

vegetable soup; choosing presto milkfish over fried catfish; choosing pepper chicken over fried chicken; choosing soy-braised vegetable over clear soup; choosing cheese cassava over steamed cassava. Salty food attitudes were assessed through daily food preferences and a 10-item visual questionnaire with yes/no responses, and each item is scored 10 points for answering prefer higher sodium food and scored 0 points if subjects preferred lower sodium food. A total sodium attitude score was derived by summing the 10 questionnaire items, so the scores in this section range from 0 to 100. A cut-off point of 60 was used to indicate a negative attitude, so a score of more than 60 points indicated a preference for high-sodium foods (Alhazmi *et al*, 2024; Haron *et al*, 2021). Its reliability was tested using Cronbach's alpha values for attitudes (0.744), indicating the questionnaire was reliable and consistent.

Practice on Salty Food Palatability

A sensory evaluation was conducted to assess the palatability of chicken soup formulations with varying salt levels. The soup consisted of carrots, potatoes, celery, leeks, garlic, and peppers, with a fixed amount of water in all formulations. The salt intensity was evaluated by incorporating varying amounts of table salt (NaCl) into five different formulations at concentrations of 0.612, 0.750, 0.875, 1.000, and 1.125 grams per 100 mL of solution, and were randomly coded to blind participants. Evaluation of the formulations involved two questions. First to assess salt sensitivity, subjects identified the saltiest soup, scoring from 1 (lowest salt, F1) to 5 (highest salt, F5). Second, the participants were instructed to choose the most palatable soup variant. The selected soup variant was used to determine the final preference for the usual formulation and the score starting with 1 (F1) and sequentially increasing to 5 (F5). The responses from both groups were examined and compared to determine statistical significance.

Energy and Sodium Intake

Energy and sodium intake were calculated based on the total food consumed in the past month using a semi-quantitative food frequency questionnaire (SQ-FFQ). The data from the SQ-FFQ were then converted into grams and analyzed using the Nutrisurvey 2007 software (EBISpro, Willstaett, Germany). The results were compared with the Indonesian Recommended Dietary Allowances (RDA) of 2019 (Ministry of Health., 2019). Energy intake was categorized as low if <90% RDA, sufficient if 90 – 119.9% RDA, or high if >120% RDA based on the Widyakarya Nasional Pangan dan Gizi (WNPG) 2012. The study categorized sodium intake into two groups: adequate ($\leq 120\%$ of the RDA) and excess ($>120\%$ of the RDA).

Table 1. Characteristics of subjects

Characteristics	OB-HT		Non-OB-HT		Total		p [#]
	n (25)	%	n (25)	%	n (50)	%	
Age group							
Mean age ± SD (years)	68.48 ± 6.862		71.56 ± 8.104		70.02 ± 7.59		
60 – 74 years	20	80	17	68	37	74	0.154
75 – 90 years	5	20	8	32	13	26	
Sex							
Male	5	20	11	44	16	32	0.069
Female	20	80	14	56	34	68	
Education level							
Not in school	6	24	6	24	12	24	0.972
Elementary/ JHS equivalent	16	64	15	60	31	62	
SHS equivalent	3	12	4	16	7	14	
Length of stay							
< 10 years	5	20	8	68	13	26	0.305
≥ 10 years	20	80	17	32	37	74	
History of Disease							
Diabetes mellitus							
Yes	6	24	2	8	8	16	0.042*
No	19	76	23	92	42	84	
Hypercholesterolemia							
Yes	4	16	3	12	7	14	0.684
No	21	84	22	88	43	86	
Hyperuricemia							
Yes	3	12	7	28	10	20	0.157
No	22	88	18	72	40	80	
Stroke							
Yes	1	4	1	4	2	4	1
No	24	96	24	96	48	96	
Drug consumption							
Antihypertensive drugs							
Yes	18	32	0	0	18	36	0.000*
No	7	68	25	100	32	64	
Cholesterol-lowering drugs							
Yes	3	5	2	13	5	10	0.297
No	22	95	23	87	45	90	
Antidiabetic drugs							
Yes	6	11	2	13	8	16	0.011*
No	19	89	23	87	42	84	
Uric acid drugs							
Yes	1	2	4	25	5	10	0.552
No	24	98	21	75	25	90	
Physical Activity							
Good	12	48	14	56	26	52	0.194
Poor	13	52	11	44	14	28	

*Significant, p<0.05. # chi-square test

Statistical Analysis

Statistical calculations were performed using the Statistical Package for Social Sciences version 25 (IBM Corp., Armonk, NY, USA). Categorical data were presented as frequency distributions, whereas numerical data were summarized using mean and standard deviation values. A normality assessment was conducted on all the datasets using the Shapiro-Wilk test. A univariate analysis was performed to delineate the frequency distribution of data characteristics, sodium-related food knowledge, high-sodium food attitude, salt-taste sensitivity, and preferences. Bivariate analysis was used to compare independent variables between the two groups. The independent variables, such as sodium-related food knowledge, high-sodium food attitude, salt-taste sensitivity and preferences, energy and sodium intake for the two groups, were analyzed in total and also stratified based on sex, male and female. The chi-square test was applied for categorical data, while the t-test or Mann-Whitney test was used for numerical data. However, for data analysis, the study aimed to use

numerical data consistently. Statistical significance was set at p < 0.05.

Ethical Considerations

This study adhered to the ethical guidelines outlined in the Declaration of Helsinki. Ethical clearance was obtained from the Health Research Ethical Clearance Commission, Faculty of Dental Medicine, Universitas Airlangga (reference no. 772/HRECC.FODM/VII/2023) before the study. Written informed consent was obtained from the nursing home administrator and each subject before their involvement in the study. The study was conducted with written permission from all subjects, ensuring compliance with ethical standards and the protection of human subjects.

Results

Subject Characteristics

The study primarily included females (68%; mean age: 70.02 ± 7.59 years), with 74% residing in a nursing

Table 2. Sodium knowledge questionnaire

Knowledge score	Total (50) n (%)	OB-HT (25) n (%)	Non-OB-HT (25) n (%)	p
Categorical data¹				
Good (>70)	19 (38)	11 (44)	8 (32)	0.674
Fair (50-70)	15 (30)	7 (28)	8 (32)	
Poor (<50)	16 (32)	7 (28)	9 (36)	
Numerical data²				
	Mean ± SD			
Total	58.4 ± 24.02	60 ± 26.14	56.8 ± 22.10	0.56
Male (n=16)	48.13 ± 21.67	42 ± 26.83	50.91 ± 19.72	0.441
Female (n=34)	63.24 ± 23.83	64.5 ± 24.60	61.43 ± 23.49	0.691
p (male vs. female)	0.029*	0.085	0.141	

*Significant, $p < 0.05$; ¹ chi-square test; ² Mann-Whitney

home for over 10 years, and most having basic elementary or junior high education. Diabetes was more prevalent in the OB-HT group (24% vs. 8%), while stroke incidence was similar (4%). OB-HT participants used more antihypertensive and antidiabetic drugs. Although both groups had managed activities, the control group had slightly higher physical activity (56% vs. 48%), but this difference was not significant (Table 1).

Sodium-Related Food Knowledge

Table 2 suggests that there was no significant difference in sodium-related food knowledge between OB-HT and Non-OB-HT ($p = 0.674$). Although females exhibited significantly higher knowledge scores than their male counterparts ($p = 0.029$), and there was a trend towards higher scores among females in both groups, stratified analysis by sex was not statistically significant ($p > 0.05$).

High-Sodium Food Attitude

Significant differences in attitudes toward high-sodium foods were observed between the two groups ($p = 0.042$). In particular, males in the OB-HT group exhibited notably higher scores on their attitudes towards salty foods than those in the non-OB-HT group. Details on the participants' attitudes towards high-sodium foods are shown in Table 3.

Salt-Taste Sensitivity and Preferences

Salt-taste sensitivity and preferences were evaluated using a menu of chicken-carrot-potato soup. The t-test results indicated no significant difference in salt taste sensitivity between the OB-HT and control groups. However, in men, the OB-HT group showed no accurate responses at F5, a noteworthy contrast with the control group. These findings suggest that male in the OB-HT group had markedly reduced salt-taste sensitivity

compared to their control counterparts ($p = 0.043$). In terms of the preferences test, the results indicate that there was no difference between the OB-HT and control groups ($p = 0.630$); however, males with OB-HT showed a higher preference for salty tastes. Additionally, a significant difference in salty taste preference was observed between males and females with OB-HT ($p = 0.021$) (Table 4).

Energy and Sodium Intake

Analysis of consumption data revealed no statistically significant differences in energy or sodium intake, despite the OB-HT group exhibiting higher sodium intake. However, for sodium intake, a notable contrast emerged within the female subgroup, indicating that the OB-HT group (1986.89 ± 425.01) exhibited greater consumption than the control group (1724.72 ± 247.71), with a p-value of 0.047 (Table 5).

Correlation between Knowledge, Attitude, Sensitivity, and Practice

The results presented in Table 6 demonstrate that practice was only correlated with attitude, not with knowledge or sensitivity. Furthermore, correlations between attitude and sensitivity only in males ($p = 0.009$; $r = 0.629$) and attitude and sodium intake in females ($p = 0.038$; $r = 0.358$) were observed.

Discussions

OB-HT presents a significant challenge to the older adult population, necessitating exploration of its associated characteristics. In this study, differences between the OB-HT and non-OB-HT groups were primarily observed in the history of DM and in the use of antihypertensive and diabetic drugs, whereas no significant differences were observed in other

Table 3. Sodium attitude questionnaire

Sodium Attitude	Total (50) n (%)	OB-HT (25) n (%)	Non-OB-HT (25) n (%)	p (OR, 95%CI)
Categorical Data¹				
Yes (score ≥ 60)	29 (58)	18 (72)	11 (44)	0.042
No (score < 60)	21 (42)	7 (28)	14 (56)	3.273 (1.008-10.621) *
Numerical data²				
	Mean ± SD			
Total	56.8 ± 24.11	62 ± 21.01	51.6 ± 26.25	0.129
Male	50.00 ± 24.76	70 ± 10.00	40.91 ± 24.27	0.023 *
Female	60.00 ± 23.84	60 ± 22.71	60 ± 25.42	0.870
p (male vs female)	0.174	0.159	0.070	

*Significant, $p < 0.05$; ¹ chi-square test; ² Mann-Whitney

Table 4. Salt-taste sensitivity and preferences in salty food formulations

Right Answer	Total (50)	OB-HT (25)	Non-OB-HT (25)	p
Salt-Taste Sensitivity				
Categorical Data¹				
Total	n = 50	n = 25	n = 25	0.915
F3	9	5	4	
F4	15	7	8	
F5	26	13	13	
Male	n = 16	n = 5	n = 11	0.122
F3	5	3	2	
F4	6	2	4	
F5	5	0	5	
Female	n=34	n = 20	n = 14	0.882
F3	4	2	2	
F4	9	5	4	
F5	21	13	8	
Numerical data²				
	Mean ± SD			
Total	4.34 ± 0.772	4.32 ± 0.802	4.36 ± 0.757	0.857
Male	4 ± 0.816	3.40 ± 0.548	4.27 ± 0.786	0.043*
Female	4.5 ± 0.707	4.55 ± 0.886	4.43 ± 0.756	0.630
p (male vs female)	0.045*	0.002*	0.622	
Salt-Taste Preferences				
Categorical Data				
Total	n = 50	n = 25	n = 25	0.630
F1	6	3	3	
F2	4	3	1	
F3	16	9	7	
F4	12	6	6	
F5	12	4	8	
Male	n = 16	n = 5	n = 11	0.097
F1	1	0	1	
F2	1	0	1	
F3	6	0	6	
F4	4	3	1	
F5	4	2	2	
Female	n=34	n=13	n=14	0.450
F1	5	3	2	
F2	3	1	2	
F3	10	7	3	
F4	8	3	5	
F5	8	6	2	
Numerical data				
	Mean ± SD			
Total	3.4 ± 1.278	3.60 ± 1.323	3.20 ± 1.225	0.273
Male	3.56 ± 1.153	4.40 ± 0.548	3.18 ± 1.168	0.046*
Female	3.32 ± 1.342	3.4 ± 1.392	3.21 ± 1.311	0.698
P (male vs female)	0.543	0.021*	0.949	

*Significant, p<0.05. ¹ chi-square test; ²Mann-Whitney

characteristics. This lack of divergence could potentially be attributed to the regulatory measures and programs implemented by nursing homes to maintain homogeneity in age, educational level, and physical activity level among residents. Consistent with this study, a study conducted in Bangladesh also highlighted the association between OB-HT and DM, with obese

individuals facing a 51% increased risk of developing DM, of which 18.64% is mediated by hypertension (Hossain, Khan and Das Gupta, 2021). The association between these factors involves a multifaceted mechanism, as linked to insulin resistance, non-esterified fatty acid levels, cytokines, hormones, and pro-inflammatory agents reported as potential causes (Wondmkun, 2020).

Table 5. Energy and sodium intake of subjects

Intake	Mean ± SD			p
	Total	OB-HT	Non-OB-HT	
Energy intake (kcal)	1453.96 ± 342.42	1388.3 ± 303.13	1519.6 ± 372.18	0.178
Male (kcal)	1754.13 ± 380.56	1711.8 ± 432.17	1773 ± 375.78	0.777
Female (kcal)	1312.71 ± 209.84	1307.45 ± 205.75	1320.21 ± 223.15	0.944
Sodium intake (mg)	1898.50 ± 375.82	1970.67 ± 423.90	1826.32 ± 312.76	0.177
Male (mg)	1940.06 ± 372.79	1905.64 ± 462.17	1955.64 ± 349.52	0.814
Female (mg)	1878.94 ± 381.21	1986.89 ± 425.01	1724.72 ± 247.71	0.047*
p-value	0.693	0.491	0.021	

*Significant, p<0.05. ¹ chi-square test; ²Mann-Whitney

Consequently, it has been proposed that antidiabetic and antihypertensive drugs, particularly ACE inhibitors (ACEIs) and angiotensin II receptor blockers (ARBs), may provide additional benefits by enhancing insulin sensitivity in patients with diabetes, as a prevalent comorbidity of obesity (Wondmkun, 2020). Therefore, the use of antihypertensive and antidiabetic drugs was higher in the OB-HT group.

Studies on salt-related knowledge in individuals with OB-HT have yielded mixed results. While one Chinese study reported increased salt-related knowledge among individuals with hypertension (Fan *et al.*, 2022; Zhang *et al.*, 2024), another study (Rusmevichientong *et al.*, 2021), along with the present study, did not find any significant differences. Notably, a Thai study emphasized that older adults with hypertension displayed a more profound understanding of the health consequences of excessive salt consumption, particularly in the development of hypertension and stroke, but not dietary salt sources ($p < 0.05$) (Rusmevichientong *et al.*, 2021). This discrepancy indicates that knowledge is not uniformly distributed across all salt-related topics. The study also found that females possess more health-related knowledge than males, possibly because of their greater interest and activity in seeking information (Ek, 2015; McKenzie *et al.*, 2018). Regular doctor visits were also identified as a significant factor in enhancing knowledge of salt-related topics and hypertension (Zhang *et al.*, 2013). As older adults with access to primary healthcare facilities have better nutrition and health literacy (Chau *et al.*, 2015), limited access to healthcare centers can negatively affect nutrition and health status. As nutrition education is frequently provided by universities, non-governmental organizations, or government organizations during community service activities, homogeneity of knowledge was observed among older adults in this study.

Although a previous study found a positive correlation between high knowledge and salt-reduction attitudes (Rusmevichientong *et al.*, 2021), this study reported the opposite. In this study, high knowledge did not appear to indicate a favorable attitude towards salt reduction, with the OB-HT group showing a preference for salty foods, especially among males. Consistently, a separate study examining dietary salt consumption among older adults with hypertension found that they preferred salted fish and added chili and salt to fruits, despite believing that adding extra salt for taste enhancement was unnecessary (Rusmevichientong *et al.*, 2021). A similar phenomenon was observed among the older population in Indonesia, who reported that awareness considerably reduced daily salt intake, despite their preference for salty flavors (Farapti *et al.*, 2020). Therefore, education and awareness are suggested to play a remarkable role in reducing 24-h urinary sodium excretion (Muthuri *et al.*, 2016). Haron *et al.* (2021) Conducted a study on the older population in Malaysia

and reported that age was extensively associated with salt reduction attitudes (Haron *et al.*, 2021). This study revealed that older adults were more likely to consume salty foods and did not perceive excess salt intake as detrimental to their health. A survey of older adults in the UK found that the factors influencing meal selection and dietary habits in this age group were food access, self-reliance (shopping, cooking, and dining alone), relationships with food, and age-related changes (Whitelock and Ensaff, 2018). Given that nursing homes manage older adults' meals, age-related changes are among the most influential factors affecting food consumption among the older population.

Age-related changes in salt consumption among older adults have been extensively studied (Wiriawattana, Suwonsichon and Suwonsichon, 2018; Farapti *et al.*, 2022, 2024; Sari, Farapti and Nor, 2022). Aging is closely associated with physiological alterations such as reduced number of taste buds, shortened lifespan of taste receptor cells, and diminished salivary flow rate, which are often exacerbated by external factors such as polypharmacy, chronic diseases, and smoking (Sergi *et al.*, 2017; Wiriawattana, Suwonsichon and Suwonsichon, 2018). Based on this explanation, it is reasonable to conclude that the OB-HT group in this study exhibited lower salt taste sensitivity, especially among males. Moreover, a large-scale study in China revealed that OB-HT is associated with a higher prevalence of diabetes, hypertriglyceridemia, high low-density lipoprotein, and hyperuricemia, and is most commonly observed in individuals aged 40–79 years (Zhang *et al.*, 2019). Additionally, it can increase the likelihood of polypharmacy in older adults (Ye *et al.*, 2022). Polypharmacy is known to cause taste disturbances, thereby altering the recognition thresholds for the four basic tastes (sweet, salty, sour, and bitter) (Kinugasa *et al.*, 2020), thereby influencing food taste perception. Antihypertensive and antidiabetic drugs commonly used by individuals in the OB-HT group have been shown to exacerbate this phenomenon. Given that ACE relies on zinc for its function, the inhibition of ACE by medications commonly prescribed for hypertension could potentially influence the zinc concentration of ACE proteins within salivary gland cells, leading to alterations in taste perception (Sari, Farapti, and Nor, 2022). Moreover, antidiabetic medications such as metformin and glibenclamide are known to produce metallic tastes that can affect both smell and taste (Asan *et al.*, 2022). This suggests that reducing salt consumption among older individuals in nursing homes may pose challenges, as they continue to favor salty foods.

Although this study found that males had lower salt sensitivity and a greater preference for salty tastes than females, there was no significant difference in sodium consumption between the OB-HT and control groups. This may be attributed to men being less selective about their food, often consuming what is served in nursing

homes. Similar findings were reported in a Malaysian study on eating habits, which found that females were more mindful of their food consumption (Wah, 2016). Another study demonstrated that males' tendency to consume larger food portions without intentionally restricting sodium intake was a key factor in their lack of adherence to low-sodium diets (Lennie, Moser, and Chung, 2020). In line with these results, the current study found that females had lower sodium intake, whereas the OB-HT group had higher sodium intake than the control group ($p = 0.047$). Awareness of reducing salt intake to reduce hypertension and obesity in females might be more important than knowledge, attitude, and preferences. Previous studies showed that elderly women had better awareness and treatment, including healthy eating (Ghaffari *et al.*, 2016; Liu *et al.*, 2017). While previous studies have extensively documented the association between high sodium intake and hypertension, this study further supports the notion that salt intake is generally higher among OB-HT groups, providing a plausible explanation consistent with the findings in other populations (Stern *et al.*, 2021). There is a strong association between high-salt and energy-dense foods (Furqonia, Farapti and Notobroto, 2023), and several studies have reported a link between salt consumption and the development of obesity. High salt consumption activates polyol pathways, leading to the production of endogenous fructose, which in turn induces leptin resistance (Lanaspa *et al.*, 2018). Furthermore, obesity resulting from high salt intake can be attributed to the interplay of the MAPK/ERK, Akt-mTOR, and inflammatory adipogenesis pathways, as observed in experiments involving salt-treated adipocytes (Lee *et al.*, 2019). In line with these findings, the PREDISE study conducted in Canada revealed a remarkable inverse association between salty foods and the Healthy Eating Index (HEI), with individuals predominantly satisfying their preferences by choosing highly processed foods that are known to contribute to obesity (Carbonneau *et al.*, 2021).

The higher salt intake observed in the OB-HT group highlights the need for targeted interventions in salt-reduction programs for older adults in institutional settings. Incorporating herbs and spices into the diet is a potential strategy that can help older adults adhere to low salt levels despite a reduction in taste perception during aging (Dougkas, Vannereux and Giboreau, 2019; Riis *et al.*, 2021; Montero and Ross, 2022; Tomić-Obrdalj *et al.*, 2023; Farapti *et al.*, 2024). It has been reported that adding herbs and spices to salt-reduced meals, along with long-term counseling, is more effective than either alone in maintaining food acceptance (Riis *et al.*, 2021). Through these measures, it appears that older adults' salt-related knowledge can be enhanced, and their attitudes and practices for reducing salt consumption can improve

over time. Therefore, this strategy remains relevant and worth considering for promoting healthier lifestyles among older adults.

The strength of this study lies in its use of a novel method, not previously employed in prior research, to gather data on knowledge, attitudes, and practices. Validation was conducted to ensure the accuracy of the obtained data. This method is also more easily applied to older adults, as these data are typically collected through complex questionnaires that are difficult to complete. Additionally, this method can help illiterate older individuals by using familiar food pictures from their daily lives.

However, assessing sodium intake using data from the SQ-FFQ has limitations compared with 24-h urine, which is considered the gold standard. Furthermore, when evaluating sodium intake in relation to hypertension, it is essential to consider potassium intake, as measuring the urinary Na/K ratio yields more meaningful results (Farapti *et al.*, 2017). In addition, although the study results were not significant, they are noteworthy, particularly given the homogeneity of the nursing home's menu. However, residents were allowed to add condiments such as soy sauce or ketchup to their meals, which could increase the salt content of their food. In addition, food brought in from outside the facility, such as during family visits, may have contributed to higher salt intake among some residents. Despite these limitations, this study is valuable in identifying gaps in dietary management in institutional settings.

Conclusion

In conclusion, this study found complex interactions between OB-HT, salt knowledge, attitudes, practices, and sodium intake in older adults in institutional settings. Despite no significant differences in saltiness sensitivity and preference between older adults with and without OB-HT, there was a notable variation in sodium-related food knowledge and attitudes, particularly between sexes. Interestingly, this study found no significant difference in sodium intake between the two groups. This suggests the need for targeted interventions, especially those considering sex differences, in salt reduction programs for older adults in institutional settings, especially for those with OB-HT. Incorporating herbs and spices into a diet may be a promising strategy to counter reduced taste perception and promote adherence to a low-salt diet. Improving knowledge about salt and promoting healthier attitudes and practices regarding salt consumption may lead to better health outcomes in older adults. However, further research is needed to assess the effectiveness and sustainability of these interventions in reducing the burden of OB-HT and related conditions among older adults.

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Availability of data and materials

The manuscript includes data supporting the results of this study. Although personal data are not publicly available for ethical reasons, they are accessible upon request from the corresponding author.

Authors' contributions

FF: Conceptualization, Methodology, Formal analysis, Writing- Review & Editing, Supervision, Project administration. ANS: Methodology, Investigation, Resources, Writing-Original Draft, Visualization. AWF: Conceptualization, Methodology, Data Curation. SRN: Supervision, Project administration. CAK: Supervision, Project administration.

Declaration of Interest

The authors declare that they have no conflicts of interest.

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